STAFF OF NIGERIAN AGRICULTURAL DEPARTMENT, OCTOBER 1st, 1926.

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Fifth Annual Bulletin of the Department of Agriculture of Nigeria.

MEASURES FOR INCREASING PRODUCTION OF PALM FRUIT IN NIGERIA.

BY

O. T. FAULKNER, B.A.

The Committee appointed by the Secretary of State to consider the best means of securing increased and improved production of palm oil and palm kernels in West Africa state, in paragraph 8 of their report, Colonial No. 10, dated March 31, 1924, and reprinted in "West Africa" April 25th, 1923, page 414a, that "it is most important that all possible steps should be taken to teach the Africans to improve the present condition of the existing trees by *cleaning the heads and opening up the bush** and to demonstrate to them the result of such improvement, *i.e.*, that they would obtain a much larger yield of fruit at a less cost of labour from an equal number of trees. They therefore recommend, in their paragraph No. 9, that "intensive propaganda on these lines (*inter alia*) should be undertaken by Agricultural, Forestry, Administrative and other officials."

These important recommendations are apparently based on a definite statement, which the Committee make in paragraph 18 of their report, that "from congested and untended wild palms in bush very little fruit of value is obtained ; that wild palms up to fifteen or twenty years of age respond to treatment and will give increased yields if systematically *pruned and cleared.*"*

The object of Part I of the present paper is to investigate the accuracy of this statement (paragraph 2 above), and thus to consider the wisdom of adopting the recommendations which follow from it (paragraph 1 above). In Part II, the social and administrative difficulties, which would be met with in putting the Committee's recommendations into practice, are briefly considered. And finally in Part III the general idea of an alternative plan is suggested.

It will be noted that the Committee recommend three separate operations (a) the pruning of palm trees, (b) the cleaning of the heads, and (c) the removal of the bush. The latter process

* The italics are mine. O.T.F.

is referred to in one place as "opening up" and in another place as "clearing," but presumably a similar process is intended in each case. It will be convenient to deal with these three operations separately in turn.

The suggestion that palm trees should be pruned is presumably based on the recommendations of this process which occur in the older literature of the oil palm. In a paper, "Communication of the General Experimental Station of the A.V.R.O.S., General Series, No. 8, 1920, page 7, Dr. A. A. Rutgers records the yields of pruned and unpruned trees for the first six months of two experiments on this point. The results of these experiments so far were inconclusive, and he therefore definitely recommended the continuance of the practice of pruning, which was then common. But in a later publication, "Investigations on Oil Palms," dated 1922, Dr. Rutgers, on pages 46 and 47, gives the yields from the same trees for a further year, which show a quite definite decrease in yield apparently due to the effect of pruning. He therefore quite definitely withdraws his previous support of the practice of pruning, stating that it is definitely detrimental, and recommends that a system be followed, which is exactly that adopted by the Nigerian native, *i.e.*, to prune no more than is absolutely necessary in order to harvest the fruit. In the meantime an experiment on this point was started at Moor Plantation, Ibadan, in May, 1922, with alternating long blocks of pruned and unpruned trees, each of 20 trees. The yields of fruit in 1922, and of bunches of fruit in 1923, are given in the Second Annual Bulletin, 1923 (page 119), and the Third Annual Bulletin, 1924 (page 80), of this department. They show that a very heavy decrease in yield apparently resulted from pruning. The effect was evidently increasing with continued treatment, and the experiment seemed entirely conclusive, especially as it confirmed Dr. Rutgers' experiments. A better example could hardly be found of the unwisdom of making any recommendations to farmers, which have not been thoroughly tested by properly designed field experiments.

In regard to the cleaning of the heads of palms, this is already done by the native on every tree from which he collects fruits. When the head of a palm tree is seen to be not cleaned, it can fairly safely be assumed that either that tree does not bear any fruit, or that fruit, for some other reason, is not collected from that tree. It appears that little benefit could be gained by propaganda in this sense.

As to the "clearing" of wild oil palms it is necessary, in order to obtain a clear view of the economic effects of any action that may be taken, to consider two theoretically separate cases, the

first when the vegetation, which is cleared away, consists of ordinary valueless bush, and the second when the trees that are removed are palm trees ; the second operation is really the "thinning" of the grove. Naturally in many wild palm groves, practical work would consist of both clearing and thinning simultaneously. Neither the authorities quoted by the Committee, nor any other known to the writer, seem to give any statistical or experimental evidence bearing on either of these two points. In a report by M. Edmund Laplae (quoted by the Committee), a bare statement occurs, which conveys the impression that the clearing of palm groves in the Belgian Congo has been very successful, but no figures are given in support of this statement. Moreover the following statement also occurs in the same paper :—"a few years ago, those that started improving these palm groves cut out the small palms and left the big ones. It looked much nicer to have trees 30 ft. high. Now it is found that big palms are often very old, and that their yield is not so high as the yield of younger palms ; Therefore, now when improving a palm grove people carefully select the trees, and as a rule keep trees that seem to be 10–20 years old." Now this latter statement leads one to doubt whether this matter has ever been investigated very thoroughly in the Congo. In the first place, the mere fact that the system has been changed so radically in the course of a few years is alone enough to suggest that it has not been very carefully studied ; but the statement that big trees in the Congo do not yield heavily, is directly contrary to our experience in Nigeria, both at Ibadan, as will be seen from the figures given in Table I herewith, and at Umuahia, where the individual yields of some 200 wild trees have been recorded for two years. So far as we can judge from our records the yield of a palm tree does not begin to fall off until it is nearly 70 feet high. Trees of this height are rare.

Some actual statistics bearing on these questions of the clearing and thinning of palms are available in the records of this department. In 1918 two contiguous acres of bush containing oil palms—both lying along and intersected by a small stream—were demarcated. [By comparison with the recorded yields from other wild palms on the department's farms, the yields given by the trees in both acres are high, doubtless due to their favourable situation]. One acre was cleared, and in the other the bush was allowed to remain. It is evident that the clearing of the one acre was carried out very thoroughly, and the stumps of the bush were dug out. This is probably a more expensive operation than African farmers would be likely to carry out. In practice, probably, all that would be done would be to cut the bush down to the ground level and repeatedly to cut down any growth springing from the stumps,

until eventually the latter were killed. It may well be that this is economically a sounder method than that followed at Moor Plantation ; but it is evident that it would be at least no more effective than the latter method ; and thus the figures given below possibly slightly exaggerate, rather than understate, the benefit that would have accrued from the ordinary method.

Until 1921, the land in the cleared acre was clean-weeded, and since 1921 it has been thoroughly and frequently cutlassed and occasionally clean weeded. The uncleared acre has remained in secondary bush which is now about 15 ft. high. No earlier estimate of the height of this bush has been recorded, but it may be noted that its increase in height since 1921 has not been obvious, so that the height of the bush then was probably already over 12 ft. Although the yields of the trees have been recorded ever since the date of clearing, and are published in the Annual Reports and Bulletins of this department, only the yields subsequent to May 1st, 1922, are dealt with below. The reasons for this are (*a*) the fact that it is evident that some considerable period must be allowed for the clearing to have an effect on the trees, (*b*) when the records were examined in the latter part of 1921, the system of checks for preventing inaccuracies appeared inadequate. Since 1922 the yield of each individual tree has been recorded with care, and the results are summarised and analysed in Table I attached.

The recorded yields that are given are those of weights of bunches of fruit. It appears preferable to deal with the gross weight of bunches, rather than the actual weights of fruits after removal from the bunches, as there is less liability of errors occurring in the former ; and the variations from tree to tree, and from time to time, in the relation between the weight of bunches, and the actual weight of fruit, are known not to be so great as to prevent reliable conclusions being drawn from such averages as those in Table I. Three or four trees have died in each area since May, 1922. The cleared acre now contains thirty-two trees of various sizes. These are confined to areas at the two ends of the plot, which constitute about five-eighths of the whole, the remaining part being entirely unoccupied. The occupied areas thus contain about 100 palms to the acre ; but they do not appear to be overcrowded ; and an examination of the figures of their yields, to ascertain whether there is any high correlation between the yield of a particular tree and its nearness to other trees, shows that there is not a high correlation of this kind. It would therefore seem that these trees are not suffering very seriously from overcrowding, and, as a matter of fact, in thinning wild oil palms

it would probably be desirable to leave just about the number which occurs in the occupied portions of this acre, *i.e.*, about 100 per acre. In the uncleared acre, a very narrow path is kept clear to each tree by cutting the bush, to a minimum extent, each time that the trees are inspected for ripe fruit, *i.e.*, at least once a month. A very small amount of bush-cutting is also necessarily done around the base of each tree and the heads of the palm are cleaned when the fruit is harvested. But all these measures are ordinarily taken by the native collector when harvesting the fruit of wild trees in bush. Indeed, it would hardly be possible to harvest the fruit without so doing, so that this uncleared acre would seem to be sufficiently typical of wild palm groves. The seventy-three palms now included in the uncleared acre are more evenly distributed than those in the clearing.

The dimensions of the trees to which the figures in columns 1, 3, 4, 9 and 10 of Table I refer are their present dimensions (April, 1925). As already mentioned, the weights given in columns 6 and 12 refer to the gross weight of bunches of fruit, which, at Moor Plantation, is on the average roughly double the net weight of the fruit after removal from the bunches. The standard "errors" given in columns 6 and 12 refer to the standard "errors" of the mean yields per tree per annum, "corrected" for the smallness of the number of trees whose yield is averaged; that is, they are calculated by dividing the standard deviation of the mean yields per annum of the individual trees in the group by the square root of the number of trees in the group, and multiplying the figure so calculated by an appropiate correction factor in accordance with that number.* The standard error of the mean annual yield per tree as given, is thus approximately one and a half times the "corrected" "probable error" of the mean annual yield, per tree. The figures given in columns 7 and 13 refer to net weights of fruit. They give the calculated theoretical annual yield of an acre of palms containing 100 trees, yielding, on the average, similarly to those in the group of trees whose mean annual yield per tree is given in columns 6 and 12, assuming the weight of the fruit to constitute one-half of the gross weight of the bunches. Thus the figures in columns 7 and 13 are obtained simply by multiplying those in columns 6 and 12 by fifty. These figures are therefore entirely theoretical, but they afford a convenient basis for comparisons. It should perhaps be mentioned that although palms are usually planted at the rate of only 60 to 70 per acre, these figures have been calculated on the basis of 100 trees to the acre, because the heads of wild palms are so much smaller, as a rule, than those of planted palms, that it would seem probable that 100 wild trees per acre is the minimum density that would give a maximum yield.

* *See* Karl Pearson.—"Biometrika" Vol. X, page 522.1915. Also "Agricultural Journal" of India Vol. XX—II—page 100.1925.

In view of the importance of the subject, it is greatly to be regretted that the number of trees in each of these groups, whose mean annual yields are considered, is not greater. But after full consideration from every point of view, I see no cause to doubt the reliability of the broad conclusions which I have drawn below from the figures in this Table. The calculated standard errors of the yields given in the Table, though high,* are yet small in comparison with the big differences in yield with which we are concerned. Again, the yields of the trees in the different groups have been examined in order to ascertain what degree of correlation there is, in the case of these particular trees, between mean annual yield and each of the following characters:—girth, distance from other trees, spread of crown, damage to trunk, and the thickened type of trunk, in which the girth at some particular point is greater than at some lower point. Only in regard to girth, does there appear to be a correlation of any high order; and the numbers of trees with particularly large or small crowns, etc., etc., in each group do not appear to be so great or so different as to invalidate the broad conclusions drawn below, even if the correlation between such characters and yield were higher than it appears to be, from the examination of these few figures. On the other hand it would undoubtedly be unwise to regard any small differences in the yields of the different groups of trees as of any significance. (It is for this reason that the figures in columns 7 and 13 of the table are given in round numbers). It may be mentioned that the main broad facts are supported by many isolated observations of various "cleared" wild palms noticed by the writer.

The effect of clearing, without any selective thinning of the palm trees, may be seen by comparing the figures in column 13 with those in column 7 of the table. It will be seen that clearing appears to have caused an increase in the yield of the trees which are less than 30 feet high, but does not appear to have caused any significant increase in the yield of the trees higher than this. It is true that in the case of the trees 30–40 feet in height there is an apparent increase in the "theoretical yield per acre" of some 330 lb., and in the case of the trees 40–50 feet in height of about 200 lb. per acre. But the standard errors of these differences work out at approximately 800 and 1,500 lb. per acre respectively, so that the chances are less than 2 : 1 against even the former difference being due to anything other than chance. Incidentally, it will be noted that in each case there is a difference of several inches in mean girth in favour of the cleared trees, which can hardly, in the case of such old trees, be due to the clearing, but which might well account for the differences in yield. It therefore appears that clearing causes an increase in the yield of trees up to

* Even among the high trees, the mean annual yields of bearing trees, varies from about 15 lb. to as much as 280 lb. bunches per annum.

about 30 feet in height, which, in proportion to their yield when not cleared, is considerable ; but has no important effect on the yield of higher trees.

But the increase in the yield due to clearing, though proportionately considerable in the case of short trees, actually amounts to a very small increase per acre. A comparison of the yield from the small trees and the high ones in each of the acres, shows that the amount of fruit yielded by the smaller trees, even those 15–30 feet high, and even in the cleared acre, is very much smaller than that yielded by the high trees, whether cleared or not. Thus, if the proportion of high trees present in a palm grove is at all considerable, as it frequently is, the actual net benefit of clearing it will be insignificant, even proportionately. For instance, of these particular two acres, the uncleared acre has given a mean annual yield of 5,147 lb. of bunches of fruit per acre, while the cleared acre has given a mean annual yield of 4,522 lb. The small benefit which has resulted from the clearing, is more than off-set by the effect of the slightly larger number of old trees which there happens to be in the uncleared area. A simple calculation will show that, of the mean annual yield of 4,522 pounds of bunches from the cleared acre during these three years, only 387 lb. per annum can, on the basis of the figures in the Table, be ascribed to the increased amount of bunches yielded by the trees under 30 feet in height as a result of the effects of clearing. It would appear that an attempt to demonstrate directly to Africans the benefit of clearing palms might well be to convince them that the process is not worth carrying out, for any benefit resulting will be of altogether too small an order for them to be able to appreciate it.

In regard to the selection of wild palm trees, it has already been mentioned that in the Congo, apparently, the old palm trees used to be retained and the small trees cut out, but that later the system was reversed. A comparison of the yields given by the small and the high trees at Moor Plantation, would seem to suggest that, in clearing and simultaneously thinning wild oil palms, one is on the horns of a dilemma. If one cuts out the high trees, and leaves the small ones, the result of the combined clearing and thinning will be to reduce the gross yield of the area very greatly for many years, until all the trees that are left reach the height of 30 feet or so. Even then the yield will still be less than if the grove had been left alone, unless there are a large number of trees, say 100, per acre, which can be retained. On the other hand, if the small trees are cut out, the yield of the area will not be appreciably affected, either one way or the other, by the clearing

and thinning. As a matter of practical economics, it would appear that the system, originally followed in the Congo, of leaving the trees over 30 feet in height is preferable to that which they are now following of keeping the trees which appear to be ten to twenty years old (*i.e.* presumably those less than fifteen feet in height).

There is, however, another argument in connection with the thinning of palms which is of considerable importance. This is connected with the fact that harvesting from high palms is said to be more laborious than harvesting from small palms. It will be seen from the figures on page 22 of the Second Annual Bulletin of this department, the substantial accuracy of which has been confirmed by further experience, that the labour of harvesting the fruit from wild trees, is, on the average, fully half the total labour of the production of hard oil. And it has always been assumed in previous discussions of the subject, that the time taken to harvest a ton of fruit from high trees is much greater than the time taken to harvest a similar quantity from plantation palms in their early years, during which the fruit can be reached without climbing. As a matter of fact, in our experience, a ton of fruit cannot be harvested so much quicker from small "plantation palms" as might be expected. It is hardly possible for me to quote figures on this subject, as owing to the many factors affecting the time taken, figures of sufficiently reliability and general application can hardly be obtained from the small areas with which we deal. But the fact that the advantage in time per ton of fruit harvested, in favour of the small trees, is not very great, will be appreciated by anyone with practical experience of such work. (It is due to the fact that the individual bunches on small trees are very much smaller than those on high trees and more leaves have to be cut in the former case).

But even though the time taken to harvest a ton of fruit be the same whatever the height of the tree, there would still remain a very important and practical advantage in favour of collection from low trees. For to climb a tall tree and cut the leaves and bunches while hanging in the rope is hard work, and it is by no means every native farmer who is able and willing to undertake it. Undoubtedly there are cases in which the fruit from tall trees is not harvested simply because the man who is entitled to harvest it is not prepared to climb the trees. Near Ibadan, for instance, if one is prepared to harvest it for himself, the fruit on tall trees can be bought for very little indeed; and the same appears to be true near Benin. It should be noted that this observation probably applies more to areas on the edge of the palm belt than to the main belt itself; but these facts indicate the handicap which the need for climbing constitutes to production.

Yet even this argument appears, on the basis of the figures given in my table, to be of little weight in regard to cleared wild palm groves, for such palms are found not to yield heavily, whether cleared or not, until they are well past the height at which the fruit can be reached from the ground, and approaching the limit at which it would probably be practical to harvest with ladders, even if that practice proves advantageous and is adopted by ordinary natives.

It is suggested that the recommendations made by the Committee, and the various representations which have been made to Government from time to time in the same sense, have been based mainly, or indeed entirely, on the well known, and very remarkable difference, between the yield and characters of young "plantation palms" and of short "wild palms," combined with an assumption that if the bush is cleared from around a small wild palm the effect is to make that small palm, in the course of a few years, practically similar to a "plantation palm." It is a fact that palms planted in a clearing as seedlings begin to yield at about the 6th year, and (at Calabar) have reached a yield of nearly two tons of fruit to the acre by the 12th year, at which time, provided they are planted at a rate of not more than 60 or 70 per acre, they are only 7—12 feet high. On the other hand, wild palms of the same height, growing in bush, yield little or nothing. But the assumption, that the effect of clearing the bush from around a small palm, which has passed the seedling stage, is the same as treating the seedling in this way, appears not to be substantiated by our experience in this trial at Ibadan, the only one of which the results are available. The short palms in the cleared acre at Moor Plantation, after six years of attention, do not compare in girth with planted palms. The figures given in the table show that their average girth is only very slightly greater than that of the similar short palms growing in bush; and the actual girth of the cleared short palms is less than 5 feet, whereas planted palms in Nigeria have a girth of 7·5 feet to 12 feet when about ten years old. The figures given in the table also show that these cleared short palms do not yield nearly so heavily as planted palms.

Naturally it can be of little importance whether a seedling from a nursery is planted, or a natural seedling is protected; but it is evident that, soon after the seedling stage has been passed, small palms in "bush" cease to be capable of responding to clearing to any great extent In other words, the Committee's statements in paragraph 18 (that "wild palms up to 15 or 20 years of age respond to treatment, and will give increased yields when systematically pruned and cleared,") as regards the clearing, seem, so far as can be ascertained, only to be true in the sense that there is a relatively

very slight response. The statement is difficult to check fully for it is, so far as is known, impossible to ascertain the age of a wild palm. So far as can be judged, the height of wild palms, fifteen to twenty years old, will vary very greatly indeed, but presumably will generally be much less than 15 feet. It has already been seen that the implication that pruning increases the yield of palm trees seems to be even more misleading.

[In connection with the above I should acknowledge the services rendered by Mr. Pedder in measuring the trees, etc.; and by the officers, Messrs. Waters and Mackie, who have supervised the collection and weighment of the bunches of fruit, etc.]

PART II.

Social and Administrative considerations.

Although it has always appeared to me that the straightforward clearing and thinning of palm groves, was a process, of which the economic soundness was unproven and questionable, it has also always appeared to me that it ought, somehow, eventually to be possible and profitable gradually to replace the wild palm groves by Native-owned "plantations of palms." Experiments bearing on the economics of various methods of establishing plantations of palms were immediately made one of the important items of the work at the Benin and Umuahia stations; and at the first opportunity an officer (Mr. S. M. Gilbert) was deputed for some two or three months to study on the spot the social, legal and administrative considerations that would be involved in any such action in connection with the land occupied by wild palm groves.

Wild palm trees occur in three distinct ways (*a*) scattered on farm lands, (*b*) as village groves around and among houses, and (*c*) in the ordinary groves.

In regard to the first class of wild trees, any treatment by pruning, clearing or increased planting, appears to be out of the question at present. The food supply of the people depends on frequent "bush-fallowing" on the farming land; and the amount of farm land is already inadequate to meet the needs of the population so long as they farm under this system. For this reason, the number of palm trees which are allowed to remain on the farm land is, I believe, deliberately limited, in defiance of the forestry regulations. The only hope of improvement in regard to palms on farming land would appear to lie in the replacement of the system of shifting cultivation by a more intensive system of farming, which, by removing the necessity for the long bush fallows will increase the average yield of food per acre, and thus possibly leave some land available for palm plantations. But no practical action on these lines is possible at present, though the subject is being thoroughly studied by field experiments.

The trees in the village groves are already generally fairly satisfactory. They serve an important purpose in shading the houses, and public opinion would probably be more opposed to any action in connection with these trees than with those in the ordinary groves. It would appear that the matter of these trees may well be allowed to stand over until trials have been made in dealing with ordinary groves.

Except in one or two special cases, in the dense, palm belt, all ordinary palm groves are regarded theoretically as the permanent and indivisible communal property of the whole village, and at present are only rarely encroached upon, in spite of the acute shortage of farming land. No vested interest, in any particular trees by any particular individual, is recognised.

In these villages, communism is combined with weak democratic rule. The village Heads or leaders have the power to interpret popular opinion, but, except in regard to matters in which their authority is actively supported by British Law and the British Administration, they have no power to carry out any measure to which public opinion is either actively or passively opposed. In view of the fact that several years must elapse before a benefit is seen from any work done to improve a palm grove, and in view of the fact that the groves are communally owned, there is no doubt that public opinion would be opposed to any attempt made by a village Head to get such work carried out. If any improvement is to be carried out at all, it appears that either the system of communal ownership of the groves must be modified, or else the work must be actively enforced by autocratic action by British authority. With regard to the latter alternative, whatever arguments may be brought forward to justify a beneficent, though unpopular autocratic action if its benefits can be quickly seen, it would appear to be outside the sphere of practical politics in a case where the benefit will only appear after the elapse of several years.

PART III.

Proposals.

The production of fruit per acre by planted palms in Nigeria seems to become equal to that of an ordinary grove after at most ten or eleven years. Thereafter, presumably, the yield of planted palms will continue to increase while that of an untouched grove remains stationary. Moreover, owing to the fact that planted palms bear fruit at a much earlier age than wild palms, the labour of harvesting the fruit of the former is less arduous than that of harvesting from the latter. Again, it has been shown in Part I of this paper, that the bulk of the fruit yielded by a grove of wild palms is given by the high trees in it. It therefore appears that

the best method of improving a palm grove would be to leave all the higher trees at first, provided they are over, perhaps, 25 feet in height, and do not exceed, perhaps, fifty per acre in density. Frequently the old trees will not be so numerous that the adoption of this standard will lead to any serious diminution in yield per acre. If, then, all the short trees be cut out, with the very rare exceptions of any that are bearing fruit and are comparable to planted palms, (*i.e.* have a girth of at least 7·5 feet at 3 feet from the ground), it would seem that sixty seedlings per acre can be planted up, or sixty natural seedlings retained, protected and "cultivated"; and, if the land is thereafter regularly weeded, they should eventually approximate to "plantation palms." It has not actually been established, by trial, that sixty seedlings per acre, raised under fifty old palms per acre, will become similar to "plantation palms". But, on the basis of general observations, it is anticipated that this may be the case. If so, this process should eventually be profitable, even though the old trees are cut down, after eight or ten years.

But, for reasons explained in Part II, there seems to be little doubt that this process will only be adopted readily if each individual (or family) is given a definite right over his (or its) own separate area, so that he who does the work may reap the benefit. It is suggested that some form of conditional individual or family rights over portions of the groves should be granted, and that the broad lines on which this should be done might be somewhat as follows:—If a certain proportion of the families of a village agrees, the groves will be parcelled out to them according to some system, on say a fifteen years lease, which is to be conditional on their carrying out the instructions that will be given in regard to clearing and planting, and with an understanding that some form of entirely permanent right, not alienable except to Government, but possibly still conditional on "proper management," will be given at the end of the period of fifteen years, if the area has been satisfactorily managed in the interim. Naturally the proposal would be carried out first on a tentative experimental scale in two or three selected villages. It might perhaps be better to give, straight away, a permanent title conditional only on proper management, etc. The rules as to the inheritance of such titles will need consideration.

In order that the proposed operation should not be illegal, it will be necessary to grant to the villages, in which the experiment is carried out, an exemption from the Forestry Regulation in regard to the cutting down of palm trees.

The major part of the palm belt is so densely populated that the people will generally desire to cultivate food crops between the "planted" seedlings in any part of the groves allotted to them, which is not too densely covered with old palms. It would probably

be undesirable to attempt to prevent them from so doing, for this seems, so far as our experience at Umuahia and Benin goes as yet, to be a very practical and economical method of establishing a plantation of palms. It is necessary to grow some crop between planted palms in the early years in order to lessen the destruction and erosion of the soil. Theoretically it might eventually be better for the palms if leguminous cover crops were grown instead of food crops. (We are experimenting on these lines). But the palms in ordinary food crops seem to do quite well; and there is no doubt that, as a practical extension measure, there is a greater chance of the people clearing and weeding the land really effectively if they are allowed to grow food crops.

It will be necessary to arrange for inspections at the end of say the first, second and third years, and thereafter at three-yearly intervals during the fifteen years lease, and to settle the procedure by which, after due warning, the "leases" are rescinded if the condition of "proper management" is not fulfilled. Naturally the first experiments would be watched more thoroughly, and the procedure in those cases could be less formal than would be necessary when the system becomes common; but I believe that it would be better to adopt, at once, methods which would be generally applicable, in order that their effect in actual practice may be ascertained as early as possible.

In view of the fact that this process, exactly as suggested, has not actually been directly tested, it might appear preferable to delay any attempt to have a trial carried out by the people themselves, until an area of palm grove has been leased by the Agricultural Department, and the matter tested experimentally. This plan would naturally appeal much more strongly to me, from a purely departmental point of view, as being safer, more certain and easier to manage.

An immediate trial under individual "ownership" is recommended, however, for the following reasons. An experiment by the Department of Agriculture on leased land would take at least ten years before conclusive results were available, and at least six or seven years before the results might possibly be predicted from the appearance of the young palms. We should then have tested the technical and economic soundness of the proposal; but we should have no more knowledge than at present as to the actual practicability of the scheme, *i.e.* whether the people will "take it up". Nor should we have any more knowledge of the practical difficulties or dangers in the proposed alteration of the custom of ownership. A trial in certain selected villages would therefore still be necessary before action on a wider scale would be safe. Thus no action on the large scale would be possible for fourteen to twenty years.

Moor Plantation, Ibadan,
8th June, 1925.

TABLE No. I.

APPENDIX I.

YIELD OF "WILD" PALM TREES AT IBADAN, MAY 1ST, 1922–APRIL 30TH, 1925.

PALMS IN 1 ACRE OF "BUSH" (A6.)

1. Height Limits.	2. Number of trees.	3. Average Height of trees to base of Crown — in feet.	4. Average Girth of trees at 3 feet from base — in feet.	5. Number of trees which have not borne any fruit during the three years.	6. Average yield of bunches of fruit per tree per annum — in pounds.	7. Theoretical yield of fruit per acre per annum — in pounds.
Below 5 feet ...	10	2·0	5·0 (at base)	2	2·2 ± 2·1	110 ± 50
5–15 feet ...	11	9·1	5·7	2	7·3 ± 2·3	360 ± 50
15–30 feet ...	8	23·3	3·9	1	27·4 ± 10·3	1420 ± 50
30–40 feet ...	14	33·5	3·8	1	21·1 ± 21·9	6100 ± 1100
40–50 feet ...	17	44·0	3·9	0	108·5 ± 17·2	5400 ± 850
Over 50 feet ...	13	54·4	3·8	0	103·7 ± 13·6	5200 ± 600
All trees ...	73	—	—	—	70·5	3525

Average actual yield per acre per annum. 5,147 lb. of bunches equivalent to about 2,500 lb. of fruit.

PALMS IN CLEARED ACRE. (Z6.)

8. Number of trees.	9. Average Height of trees to base of crown —in feet.	10. Average Girth of trees at 3 feet from base — in feet.	11. Number of trees which have not borne fruit during the three years.	12. Average yield of bunches of fruit per tree per annum — in pounds.	13. Theoretical yield of fruit per acre per annum — in pounds.
12	2·1	5·6 (at base)	6	8·3 ± 4·4	415 ± 200
9	8·7	5·7	1	21·4 ± 9·7	1070 ± 500
13	22·2	4·5	0	73·4 ± 12·1	3700 ± 600
14	35·9	4·3	1	127·8 ± 20·3	6400 ± 1000
11	43·0	4·0	0	112·4 ± 23·7	5600 ± 1200
3	54·3	3·7	0	85 ± ?	4200 ?
62	—	—	—	72·9	36·5

Average actual yield per acre per annum. 4,522 lb. of bunches equivalent to about 2,250 lb. of fruit.

FUNGOID DISEASES OF COTTON IN SOUTHERN NIGERIA.

BY

T. LAYCOCK, A.R.C.SC., D.I.C.

In special papers appearing in the last two Departmental Bulletins considerable prominence has been given to the factors inhibiting the development of the cotton plant in Southern Nigeria, and it appears desirable to summarise our knowledge of the occurrence of the fungoid pathogens mentioned and to outline the extent of the damage for which each is responsible. Our experience has shown that the incidence of some of these pests has fluctuated considerably during different seasons and, although we have arranged our list according to their economic importance, it must be clearly understood that some factors responsible for considerable loss of crop in one season have had a negligible incidence at other times. The fungoid pests causing rotting of cotton bolls and staining of lint are given the primary position in the following list.

Internal Boll disease. This term is used to describe the damage produced by a specific fungus which is still undetermined but which is closely related to the genus *Nematospora.** Occasionally other fungi are found associated with this, each of which adds its quota to the general damage, but the description given herewith is concerned solely with the effects of the *Nematospora* (*?*) fungus.

Evidence has already been produced which proves fairly conclusively that this fungus is carried and introduced within the cotton boll by various species of the cotton stainer bug *Dysdercus* (1 but from the fact that this fungus is introduced by the earliest stainer migrants it would appear that it occurs on plants other than cotton. No alternative hosts of the fungus have been noted in Nigeria, however, although two occur in the West Indies namely *Datura metel* (2)., and asclepias curassavica.

There are no external symptoms of this disease and affected bolls have usually a normal healthy appearance. The disease is purely internal and the extent of the rot produced depends upon the time of infection. Should this occur early in the development of the boll the entire contents become rotted; the seeds are rendered soft and pasty, and the lint stained a dark yellow to black. If infection takes place late in the boll's history the staining is more localised and only a few seeds may be affected whilst other locks within the same boll may be perfectly normal. The fungus freely

* This fungus has now been named Nematospora gossypii. *See* paper by Ashby (S.F.) and Nowell (W.) entitled "The fungi of stigmatomycosis." Ann. of Botany, XL, 157, p.p. 69-83, 1926.

sporulates both in culture and within the cotton boll and the time taken to obtain complete infection is very short, sporulation having been noted within the lint fibres of the boll six days after inoculation. *Nematospora* (?) has a non-septate mycelium normally and septa are only formed in fertile hyphae when sporangia are produced. The spores are spindle-shaped and occur in two bundles within the sporangium. They are flagellate and the bundles are united by the flagellae. There are from one to five or more spores in each bundle. In affected open bolls these spores are very numerous and are found entangled amongst the stained lint and frequently within the lumen of affected fibres.

The damage caused by the disease may be complete or partial depending as we have seen upon the the age of the boll at the time of infection. The fungus also acts as a boll-shedding factor, particularly amongst young bolls, but it is not possible to assess the loss in this connexion for we cannot differentiate between direct damage due to stainer injury and the more diffused damage due to the activity of this fungus. It is possible to assess the damage to open bolls and the table below gives the loss for the seasons 1923 (3) and 1924.

TABLE I.

Year.	Percentage Total Locks affected by Internal Boll Disease.			Percentage Total Seed Cotton stained.		
	American Cotton Allen Variety.	Native Cotton Meko Variety.	Native Cotton Ishan Variety.	American Cotton Allen Variety.	Native Cotton Meko Variety.	Native Cotton Ishan Variety.
1923 ...	35·2	12·7	No record	28·0	41·1	No record
1924 ...	19·8	23·2	10·1	16·6	27·6	7·0

In addition to this percentage of low grade or useless lint there is the complete loss of crop which is left as shrivelled mummied bolls upon the plants and the Internal Boll Disease fungus must be counted as one of the many factors bringing this about.

The control of this disease is an entomological problem and, undoubtedly, insects act as precursors not only of this pest but of most of the fungoid rots of cotton bolls where the causal pathogen first gains entry to the boll through the lesions produced by bugs or boll-worms.

Anthracnose Disease of the cotton boll is caused by the fungus *Glomerella* (*Colletotrichum*) *gossypii*, (Southw.). It has assumed an incidence of great importance in certain seasons whereas at other times it has been unimportant. The disease affects native cotton principally, and during the 1924 season the percentage of mature bolls having Anthracnose lesions was as follows, American (Allen variety) 1·9, Native (Ishan variety) 2·39 and Native (Meko variety) 25·1. The disease does not usually occur on young bolls and, indeed, the inception of this pest does not occur until the season has been well advanced. Its greatest damage is, therefore, to the late crop. It has already been suggested (1) that severe harmattan conditions, reacting adversely on the cotton plant, favour the spread of this disease. It is probable too that the low temperature at this time promotes the growth of the fungus. Certainly, high temperatures inhibit its growth in culture and when incubated at 32°C the growth rate was not half of that at the laboratory temperature (26°C). The fungus appears to be only a weak parasite. In experiments during the 1925 cotton season (when the incidence of Anthracnose was small) 25% of the bolls artificially inoculated were infected. The inoculation was carried out by pouring a spore suspension into a glass ring affixed to the cotton boll by means of a strip of cloth. The lower portion of the ring where it rested on the boll had a small pad of aseptic cotton wool which was made to adhere by a smear of Canada Balsam. This assisted in retaining the spore suspension for a short time within the ring. The experiment was commenced when the harmattan was most severe, *i.e.*, the minimum temperature was 49°F. Spore suspensions were given at various times and six times in all. Twelve bolls were treated in this manner but infection only took effect in three cases, one after twelve days, another after thirty-three days and the last after forty days.

Inoculations after stainer and boll-worm injury were not very successful but, in all cases where the boll-worm lesions penetrated through the boll-wall, infection resulted. In only two cases was the fungus stroma produced on the boll wall when stainers were introduced to twelve cotton bolls sprayed with a spore suspension. There would appear to be some correlation between boll worm attack on mature bolls and the incidence of the fungus: for in the season 1923 the percentage damage on Meko cotton due to boll-worm was 5·7 and the fungus was practically absent, whereas in 1924 when the incidence of the fungus was high the boll worm damage was as much as 14·2%. Physical factors affecting both the cotton plant and the fungus must also operate in producing the fluctuating incidence of Anthracnose.

The lesions produced by *Glomerella gossypii* are often large and involve the whole of one or more locks. The fungus stroma is dark pink, compact, and exhibits zonation. The contents of the boll may be completely rotted the lint being yellow, brown or dark grey. Affected bolls usually only partially open and show inequalities of growth due to shrivelling of the affected boll wall.

Control.—Seed treatment is advocated for this disease and, indeed, on general grounds external seed disinfection appears desirable particularly for the indigenous varieties of cotton. Control of insect pests is also desirable in checking this pest.

Fusarium Rot of cotton bolls caused by an undetermined species of *Fusarium* appears constantly on native cotton bolls every season, and invariably follows the lesions due to the bacterium *Pseudomonas malvacearum.* Unlike Anthracnose, which is confined to the cotton boll, this fungus appears on the whole of the plant, leaves, stems and bolls. In wet seasons it may cause considerable damage. Although occurring every year experiments have demonstrated that it is not so virulent a boll rotting factor as is Anthracnose. As it is always associated with Angular leaf spot and Black-Arm diseases of cotton it follows that if these bacterial pests are plentiful a considerable amount of infecting material is produced and is ready at hand during the period of boll production.

The fungus also appears on bacterial and insect lesions on the bolls, and experience this last season show that it is a factor causing bud shedding. In this connexion the whole of the stamens are rotted and black. Inoculation experiments with a spore suspension, obtained from a pure culture of the fungus isolated from rotted buds, gave ten infections out of twelve, and the whole of the infected buds were shed within six days. These results were obtained after needle punctures and the fungus does not appear to be parasitic for no sheds were obtained on unwounded buds. Probably the fungus enters through insect lesions.

Fusarium sp. can only be regarded as a saprophytic but its constant association with the bacterial lesions gives an additional reason for the necessity of applying control methods for the latter disease. The fungus produces a light pink loosely compact stroma and within the boll causes the affected lint to be stained a bright yellow.

Pseudomonas malvacearum. (E.F.S.) Lesions due to this bacterium appear every season on the vegetative parts of native plants but occur only rarely on the American variety. The disease, which is known as Angular Leaf Spot, was described by Farquharson in 1912 (4) as a "black vein" disease of leaves. It is characterised by water-soaked areas of irregular angular shape which usually

follow the venation of the leaf. They eventually become dark brown or black. The disease also appears on the branches which the lesions completely encircle and "ring" so that the whole of the leaves and bolls of the affected branch are killed and lost to the plant. The appearance of the disease on the stems is described as Black Arm disease. The disease is seed borne and it has been demonstrated that the method of seed treatment of Faulwetter (5) when applied to a tenth-acre plot of Meko cotton on Moor Plantation gave complete control of the Angular leaf spot and Black Arm diseases. Boll rots attributed to *Pseudomonas malvacearum* did occur on these plants and it would seem probable that the cause of bacterial rots may be some other saprophytic bacterium which gains entrance through insect punctures. In the early stages of bacterial attack on the bolls it has constantly been noted that the lesions arise around bug punctures. It certainly does not appear to have been proved that a correlation exists between the affections on the leaf and on the boll. From records made by Mason and Jones (3) in 1923 and by Jones and the writer in 1924 the amount of damage caused by this factor has been determined and is given in the table below.

TABLE II.

Type of Cotton.	Season 1923-24.			Season 1924 25		
	% Bud Sheds.	% Boll Sheds.	% Damage to open bolls.	% Bud Sheds.	% Boll Sheds.	% Damage to open bolls.
American (Allen) ...	5·4	12·0	4·8	0·7	1·1	0·1
Native (Meko)	14·8	18·7	0·7	4·4	6·8	2·6
Native (Ishan)	No record during this season			1·1	1·5	0·5

It will be noted that the damage due to bacterial disease was not important during the season 1924 and the same applies to leaf damage from this source. In 1923 the percentage reduction in leaf area brought about by this agent was as high as fifteen on Meko and five on American cotton whereas in 1924 it was only 3·7 on Meko and practically absent on American. The loss of leaf area will be shown later to be even less during the season 1925. Our experience during the past two seasons indicates that the disease is not so important as was once thought and examinations made by the writer on numerous native farms show that Angular leaf Spot appears there to a much less extent than on Moor Plantation.

Reports and specimens sent from various outstations in the Northern and Eastern Provinces show that the disease is present there during the rains. It does not appear to occur in the rain forest zone of the Southern Provinces.

American cotton plants show considerable immunity to these diseases.

Alternaria disease.—This fungus has been demonstrated by Jones to cause boll shedding. It appears to be more prevalent in damp districts than in the more open country. The fungus lesion is usually at the base of the boll in the glandular area between the bracts but is sometimes found on other parts of the boll in which position it has been found to produce internal rotting. The fungus also occurs on the leaves where it forms circular brown lesions which exhibit zonation. *Alternaria* also produces long elliptical lesions on the leaf stalks and flower pedicels, and in the former position several lesions may coalesce and completely ring the stalk causing defoliation.

*Diplodia rot** of the cotton boll has recently been noted but is only rarely met with. It occurs on matted locks which it discolours a dark grey. The affected lint contains numerous fungus hyphæ within the lumen of the fibres. The pycnidia have only been noted on affected cotton in damp chambers.

Arcolate Mildew of cotton is caused by the fungus *Ramularia arcola* Atk. and appears every season on the leaves of native cotton. The lesions resemble those of Angular leaf spot in shape, position and size but are white and powdery whereas the latter are brown or black and shiny. The fungus appears only to produce minor damage.

Leaf Rust disease due to *Kuchneola desmium* (B. and Br.) occurs on the leaves of all varieties of cotton but more particularly on American (Allen). It only occurs late in the season and is usually limited to old moribund leaves. It is of little importance.

Damping off disease has occurred on a few rare occasions. It is caused by the fungus *Sclerotium bataticola.* (Shaw) It only appears on cotton seedlings during damp conditions and is of little importance.

General conclusions.—1. American cotton shows considerable immunity to fungoid pests excepting those which gain entrance through injuries to the boll due to insects.

2. Of the insect borne fungi which affect both American and native cotton bolls *Nematospora* (?), the specific fungus of internal Boll Disease, is by far the most important.

* The fungus does not appear to differ from the type in Kew Herbarium of *Diplodia gossypina*, Cke.

3. Bacterial diseases due to *Pseudomonas malvacearum* (E.F.S.) are not important on the American variety but during wet seasons might cause considerable damage to the indigenous varieties. Their control by seed disinfection is advocated because in addition to the damage resulting from them there is the boll rotting potentialities of the saprophyte *Fusarium* which is invariably found associated with the bacterium.

4. More data is required before we can fully understand the fluctuating incidence of Anthracnose boll rot disease, although it does appear to be correlated with severe harmattan conditions and high boll-worm incidence.

5. The importance of control measures with regards to insect pests cannot be over-emphasised. Needle inoculations with six different fungi have resulted in boll-rots and, as the contents of developing cotton bolls are comparable with nutrient broth cultures, it will be easily understood that even saprophytes, gaining access to the interior of the boll through insect lesions, may find the conditions very suitable for their further development and produce boll rots.

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THE RECOVERY OF PALM KERNELS,

BY

A. C. BARNES, F.I.C., B.SC., A.M.I.CH.E.

In the descriptions of investigations on the extraction of palm oil by native and mechanical processes, the methods adopted for recovering the kernels from the nuts have been briefly discussed. During the course of the work involved, a number of interesting observations was recorded; but until recently it was not possible to give more than passing attention to matters connected with the preparation of nuts for cracking, and the separation of the kernels from the mixture of broken shell and kernels after cracking. The operation of mechanical crackers has to some extent been discussed, so that in the course of the present article it will not be necessary to refer more than briefly to them.

Native methods.—In native processes, the nuts are spread out in shallow layers for some weeks in the open to dry before being cracked. It is not usual to protect them from rain during this period, so that there is risk of water penetrating through the apical pores of the nuts to the kernels, and of the kernels becoming mouldy within the nut by the development of spores introduced in the same manner. This effect has been observed with nuts at Moor Plantation.

The object of the air drying is to separate the kernel from the inner surface of the shell, to which in the natural state it is firmly attached, and to enable the nut to be cracked with the minimum of damage to the kernel in such a manner that the latter separates cleanly. In some districts, the nuts, after having been exposed to sun and air for a time, are carried inside the huts and kept under cover until they are cracked. Racks fixed over the place where the fire for cooking is situated are occasionally used for storing nuts.

One method for cracking the nuts is to place them on a stone having a number of small depressions to hold them in position, and to give them a sharp blow with another stone, or a short iron bar. The kernels are picked out by hand and the shell discarded. Hand operated mechanical crackers are used to a very limited extent.

Rapid preparation of nuts for cracking.—Early in 1924 it was observed that the kernels could be loosened within the shell by subjecting the nut to the action of steam at atmospheric pressure for one hour, and that two hours treatment achieved the same result in this direction as four to six weeks air drying. Further work has been done on this subject, and will now be described.

The steaming of the fibre-free nuts from the fruit immediately after the palm oil was extracted from it was carried out in two ways:—(*a*) in a steam oven, fitted with trays each holding twenty-five pounds of nuts, under a pressure of 2½ lb. per square inch; and (*b*) in the steam cookers, used in the Cooker-Press process at slightly above atmospheric pressure.

In each case, the nuts were discharged immediately after the conclusion of the period of steaming, and were kept overnight in a shallow layer on a concrete floor under cover. They were then cracked by a "Delta" palm nut cracker running at 1,350 r.p.m. (method *a*), and 1,500 r.p.m. (method *b*).

The period of steaming was varied with different batches. Unsteamed nuts were also put through the cracker in order more clearly to demonstrate the loosening effect of the steaming on the kernels within the nuts.

The mixture of uncracked nuts, shell, and kernels was separated by hand picking. The "cracking efficiency," *i.e.*, the percentage of nuts completely broken, was calculated from the difference in weight between the nuts originally taken, and the unbroken and partially broken nuts (nuts with a portion of the shell broken away, but with the kernel still unseparated). By this method an approximate figure for the cracking efficiency is given, as some of the shell from the partially cracked nuts is credited to the weight of those completely broken. The results are thus slightly higher than the true ones, as obtained by counting the original number of nuts, and those unbroken or partly broken after passing through the cracker. The degree of error introduced by the weighing method is reduced as the proportion of completely broken nuts increases, and as the object of the work was to determine the conditions necessary to the highest efficiency, no attempt has been made to apply corrections. Above seventy-five per cent, the error is sufficiently small to be negligible.

The unbroken and partially broken nuts were put through the cracker again without further treatment, as it was observed that with the latter, the kernels were loose, but had not separated because the shell had not been sufficiently shattered by one passage through the machine.

The nuts used for experiments 1 to 4 were obtained from fruit of the common thick-shelled variety, depericarped by the Culley process. Nuts used for similar experiments with the Rapid and Pioneer cookers were obtained from fruit extracted by the cooker press process (q.v.)

1. *Experimental details.*—Nuts freshly extracted,—no steaming apart from that for the cooking of the fruit prior to extraction of the palm oil.

Total weight of nuts put through cracker ... 18 lb. 8 oz.

	lb.	oz.	
Unbroken	4	0	
Partially broken ...	5	11	
Kernels	1	5	High proportion broken.

Cracking efficiency ... ... 47·6

Composition of Kernels.

Moisture	19·75	per cent.
Oil	44·4	„ „
Oil: dry kernels	55·3	„ „
F.F.A. of oil as lauric acid	0·3	„ „

2. Nuts steamed for 90 minutes at 2½ lb. per square inch.

Total weight of nuts ... ... 170 lb. 10 oz.

1st cracking—

	lb.	oz.	
Uncracked	24	12	
Partly cracked	29	4	
Total kernels	23	14	
Broken kernels	3	0	
Cracking efficiency	68·3		
Broken kernels	8·0	per cent.	

2nd cracking—

Partly cracked nuts from 1st cracking.

	lb.	oz.
Still incompletely cracked ...	12	9
Total kernels	8	7
Broken kernels	1	2

Uncracked nuts from 1st cracking.

	lb.	oz.
Incompletely cracked	2	7
Total kernels	4	1
Broken kernels	0	5
Cracking efficiency, including nuts cracked on second passage through machine	91·2	
Total broken kernels	12·2	

Composition of kernels.

Moisture	17·9	per cent.
Oil	45·0	„ „
Oil : dry kernels	54·9	„ „
F. F. A. of oil as lauric acid ...	0·2	„ „

3. Nuts steamed for 2 hours 20 minutes at 2½ lb. per square inch.

Total weight of nuts ... ... 187 lb.

1st cracking.

	lb.	oz.
Uncracked	19	12
Partly cracked	19	10
Total kernels	24	8
Broken kernels	1	6
Cracking efficiency		79
Broken kernels		6·4 per cent.

2nd cracking.

Partly cracked nuts from 1st cracking.

	lb.	oz.
Still incompletely cracked ...	7	8
Total kernels	6	12
Broken kernels	0	13

Uncracked nuts from 1st cracking.

	lb.	oz.
Incompletely cracked	2	15
Total kernels	5	4
Broken kernels	1	0½
Cracking efficiency, including nuts broken on second passage through machine	95·6	
Total broken kernels	8·8 per cent.	

Composition of kernels.

Moisture	18·1	per cent.
Oil	45·2	„ „
Oil : dry kernels	55·2	„ „
F.F.A. of oil as lauric acid ...	0·2	„ „

4. Nuts steamed for 3 hours at 2½ lb. per square inch.
Total weight of nuts ... ... 115 lb.

1st cracking.

	lb.	oz.
Uncracked...	15	12
Partly cracked	17	8
Total kernels	17	15
Broken kernels	1	9
Cracking efficiency		71
Broken kernels		8·7 per cent.

2nd cracking.

Partly cracked nuts from 1st cracking.

	lb.	oz.
Still incompletely cracked ...	8	11
Total kernels	3	13
Broken kernels	0	$10\frac{1}{2}$

Uncracked nuts from 1st cracking.

	lb.	ox.
Incompletely cracked	0	15
Total kernels	3	15
Broken kernels	0	3
Cracking efficiency, including nuts broken on second passage through machine		93·6
Total broken kernels		9·3 per cent.

Composition of kernels.

Moisture	17·5 per cent.
Oil	45·3 „ „
Oil: dry kernels	54·9 „ „
F.F.A. as lauric acid	0·2 „ „

5. Method (*b*). 155 lb. nuts steamed for 2 hours in Pioneer Cooker.

Cracker efficiency, 1st cracking	84·7 per cent.
1st and 2nd crackings	93·5 „ „
Total broken kernels	12·5 „ „

6. Method (*b*). 54 lb. 5 oz. steamed for 2 hours.

Cracker efficiency, two crackings	87·5 per cent.
Total broken kernels	25 „ „

The high proportion of broken kernels in Nos. 5 and 6 was attributed to the fact that the cracker drum was rotating at too high a speed. With air dried nuts, the proportion of broken kernels was 36 per cent. and 50 per cent. in two instances. From these figures, it is evident that the kernels from steamed nuts are not so easily broken as those from air-dried nuts.

Drying the Kernels.

It is not possible to bag and export palm kernels containing a high percentage of moisture without heating and deterioration. The moisture content of commercial samples of kernels ready for export ranges from 7 per cent. to 9 per cent., so that the kernels from the steamed nuts must be dried until they contain not more than 9 per cent. of moisture. This may be done by exposing them in the open in shallow layers to sun and air for two days, or drying them in the shade for seven days. In the former case, the surface of the kernels becomes very oily, while in the latter it does not. It therefore appears preferable to dry the kernels in the shade, turning them over at frequent intervals.

The following figures illustrate the results of drying by the two methods.

(*a*). Kernels dried in the sun.

Original moisture content	...	19·9 per cent.
Moisture content after two days		7·6 „ „

(*b*). Kernels dried in the shade.

Original moisture content	...	21·0 per cent.

Moisture content after drying for :—

89 hours	...	...	...	12·2 per cent.
119 „	...	...		10·8 „ „
146 „	...	...	...	9·4 „ „
171 „	...	...	...	9·0 „ „
218 „	...	...	...	9·0 „ „

The Separation of Palm Kernels from Shell after Cracking.

Apart from hand-picking, there are at least two possible methods for the separation of the kernels from the mixture discharged by the cracker. Both depend for their efficacy on the fact that the densities of the shell and unbroken nuts are greater than the density of the kernels, so that by using a suitable liquid of such density that the kernels float, while shell and unbroken nuts sink, the kernels can be separated by skimming.

The methods involve the use of (*a*) a brine bath and (*b*) a mud bath, or clay suspension. The former is cleaner in action, but expensive, in that salt is carried away in solution on the surface of the kernels and cannot be entirely recovered. The latter is equally effective, and requires the use of no imported material, except in the case of large capacity mills, where with either method, specially designed machinery and baths are necessary.

The use of mud baths for this purpose has often been referred to in literature on the subject of palm fruit and kernels. The natives in certain parts of Nigeria practise the method, and the Dutch in Sumatra are familiar with it. In the description of English Patents Nos. 206, 181; 206, 536 and 206, 762, by Moseley, Dyke and Lever Brothers, Ltd., it is stated that "the kernels can be separated by any of the usual methods, but preferably by means of a process in which a suspension of clay is employed as the flotation medium."

In view of the possible introduction of mechanical crackers in Nigeria, it appeared advisable to investigate the subject experimentally, since hand-picking, or the use of brine baths would not be economically possible for employment in conjunction with small capacity installations.

Preparation of the Mud Bath.

The liquid for the flotation medium consists of a suspension of clay in water, so that a soil containing a high proportion of clay is essential as a basis for its preparation. A wide mouthed vessel of suitable size, such as an iron cauldron or an earthenware pot is used. This is half filled with water, and the clayey earth added and thoroughly mixed with the water. The heavy particles of soil, stones, etc., which fall to the bottom are scooped out and discarded. Any foreign matter floating on the surface is removed.

During the course of the mixing, kernels are thrown into the clay suspension, and when these float, the bath is ready for use. Its apparent density may be tested by a hydrometer, as in the case of the brine bath, but the use of kernels for the purpose is simple and satisfactory, and enables the native to judge when he has obtained the correct mixture. Adjustments may be made as required by adding water or earth.

The Separation of the Kernels.

The mixture from the cracker is thrown in portions into the bath, stirred with the hands, and allowed to stand for a few seconds. The floating kernels are removed by a perforated bowl or calabash, and placed in another vessel containing clean water. The mixture is again stirred to achieve as complete separation as possible. During the course of the removal of the floating kernels, the liquid is gently stirred in order to keep the clay in suspension.

The shell, which contains any unbroken nuts, is scooped out and discarded. Small quantities of kernels, which owing to their higher density are not separated from the shell, may be thrown out

with the latter. This is inevitable with a flotation process, unless the density of the liquid is so adjusted that all the kernels float, when lighter particles of shell, and even unbroken nuts will float and be skimmed off with the kernels in greater quantity than is desirable.

The separated kernels, with which are mixed small quantities of shell, are removed from the water, washed again, drained, and spread in shallow layers to dry, being turned over at intervals. A few hours in the sun are sufficient to dry them fully if the nuts from which they were obtained were thoroughly dried before being cracked. In the case of steam-heated nuts cracked the day following the extraction of the oil from the fruit, the kernels contain upwards 20 per cent. of moisture, which must be reduced to the normal figure of 9 per cent. or less for commercial kernels. Two to three days sun drying, or seven days air drying in the shade are sufficient. (*vide* page 29).

The results of some observations of this method are recorded below.

1. 100 lb. nuts, air dried for 9 months, cracked by "Delta Junior" cracker running at 1,500 r. p.m.

   Cracker efficiency 98 per cent.

   Kernels broken 50 per cent. This was due to the dryness of the kernels, and the high speed of the cracker drum.

   Total kernels separated 20·1 lb.

   Kernels left in bath 0·47 „ or 2·3 per cent.

   Shell and fibre in separated kernels 3·1 per cent.

   Dirt adhering to kernels after two washings 0·27 per cent.

2. 100 lb. kernels from same batch as No. 1, similarly treated.

   Cracker efficiency 94 per cent.

   Kernels broken 37 „

   Total kernels separated 18 lb.

   Proportion of kernels left in bath 2·5 per cent.

   Shell and fibre in separated kernels 1·5 per cent.

3. 155 pounds steam heated kernels. (*Vide* No. 5, page 28). Kernels left in bath 0·6 per cent. of total.

Summary.

1. Palm nuts may be prepared for immediate cracking by subjecting them to the action of live steam for two hours, and cooling them before feeding to the cracker.

2. The speed of rotation of the cracker drum influences the proportion of broken kernels as well as the cracking efficiency.

3. The separation of kernels from shell and unbroken nuts may be satisfactorily effected by means of a suspension of clay in water.

4. Kernels from steam heated nuts must be dried before export. Two days' sun drying, or seven days' air drying in the shade reduces the moisture content of such kernels to the normal figure characteristic of commercial grades of kernels.

Moor Plantation, Ibadan,

April, 1926.

AN IMPROVED PROCESS FOR THE EXTRACTION OF PALM OIL BY NATIVES.

THE "COOKER-PRESS" PROCESS.

BY

A. C. Barnes, F.I.C., B.Sc., A.M.I.Ch.E.

The investigation of possible lines of improvement of native processes for the extraction of palm oil, without introducing simple machinery, has led to the conclusion that although the quality of the extracted oil may be improved by the exercise of greater care in the preparation and cooking of the fruit, the yields are not capable of being increased unless special apparatus is used. The "modified" process, which in comparison with the "soft" oil extractions carried out at the Moor Plantation by paid labour, promised to provide a solution of the problem, has been shown by trial in the field to be not better than, if not actually inferior to the "soft" oil process as worked by labour directly interested in the results of extraction. Recent investigations show that the efficiency of the "soft" oil method, instead of being thirty-five per cent. to forty per cent., as concluded from observations of extractions performed by paid labour, is from forty-five per cent. to fifty per cent.

The results of extractions carried out by the "hard" oil method and the "modified" method at Moor Plantation, and by the "modified" and "soft" methods at Oloburo, indicate that the apparent order of efficiency of the three processes is (1) "soft," (2) "modified," (3) "hard."

Consideration of two methods for the extraction of "soft" oil, in one of which the fruit is cooked, mashed, treated in a pit with a large volume of water, and the scum removed and heated to separate the oil, while in the other the water treatment is replaced by hand separation of the pericarp and squeezing, leads to the conclusion that the main faults with the methods are (1) inefficient cooking; (2) loss of oil in the water extraction of the former method; and (3) loss of oil by inefficient squeezing in the latter method.

The various points in connection with the cooking stage have been dealt with in previous publications, and it is clear that from the points of view of economy of fuel, water, and labour, steaming in an efficient form of steam cooker is superior to the wet cooking in native earthenware pots or iron cauldrons as practised at present.

The serious loss of oil caused by the formation of a fine suspension of oil in water during one stage of the "soft" oil process has also been commented upon, and the inefficiency of hand squeezing or wringing of oily pericarp is sufficiently obvious.

From these considerations it would appear that proper cooking, the avoidance of the water extraction stage, and efficient pressing in a small hand operated press, should improve the yield and quality of the oil. Reference to the tabulated results of a number of "Cooker-Press" extractions will show that this is actually the case.

Apparatus.

The apparatus required for the "Cooker-Press" process comprises:—

(*a*) A fruit cooker, with one five gallon container and lid.
(*b*) Wooden mortars and pestles.
(*c*) A hand screw-press.
(*d*) Vessels for collecting and purifying the oil.
(*e*) Flat galvanised iron sheets.
(*f*) Baskets for the fruit.

(*a*). *The Fruit Cooker.*

The best form of fruit cooker is the "Rapid"* steamer, or its later modification, the "Pioneer"* palm fruit cooker. The former has already been described, and the principle of the latter is similar, except that improved means of discharging the cooked fruit are provided.

The "Pioneer" cooker is essentially a fifty gallon iron drum mounted over a furnace. The lower portion of the drum, as with the "Rapid" steamer, is surrounded by a jacket so that the hot furnace gases may exercise a slight superheating effect on the steam within, thereby making the apparatus more efficient. The drum is closed at the top by a tightly fitting lid secured in position by a length of gas-pipe which passes through holes in lugs at the sides of the drum and a clip in the middle of the lid. The arrangement for tipping is ingenious. At each side of the drum, about halfway down, a toothed quadrant is fitted, and a rack is fixed at each side of the base in such a manner that when the drum is pulled over by means of a lever attached, the teeth of the quadrants engage with holes in the racks and the drum rolls forward. It tilts at the same time until it has passed the horizontal position, when it is prevented from further movement by the upturned ends of the racks which act as stops. Thus, with the lid removed, the whole or

* Manufactured by Messrs. Burford & Perkins, Ltd., Peterborough.

any portion of the contents may be discharged with the minimum of effort and trouble. The apparatus is so constructed that it is stable with all positions of the drum. The latter is secured in its vertical position by a simple device attached, or may be fixed without danger of tipping accidentally by a short piece of wood inserted between one of the stops and the topmost tooth of the corresponding quadrant.

Instead of a cone and perforated pipe, as in the "Rapid" steamer, the "Pioneer" is fitted inside with a perforated plate with short feet resting on the bottom, so that the fruit does not come into contact with the water. This plate may be readily removed when required by means of the handle provided.

The capacity of this cooker is 350 pounds of palm fruit. Two to three gallons of water are sufficient to cook this amount of fruit, and very little fuel is required. Any kind of dry combustible refuse may be burnt in the furnace; bunch refuse, shell, and exhausted fibre have been used in the course of various experiments.

A five gallon drum having long handles at the sides, and a tightly fitting lid, is required for reheating the once pressed pericarp. A stand which fits inside the cooker, and on which the pericarp container may rest, should also be supplied. It would, perhaps, be better to have a double container, or one of larger size, in order to economise in fuel and time. For the experimental work, enamelled buckets with lids have been used with satisfactory results.

The double-vessel cooker made from a 40 gallon oil drum has been used in connection with this process, but is not so suitable as the "Rapid" and "Pioneer" cookers. Boiled fruit, as in the native "soft" oil process, cannot be extracted with satisfactory results by the press process.

(*b*) *The mortars and pestles* are used to mash the hot fruit, thereby stripping the pericarp from the nuts and setting free the oil. In this process it is not possible to tread the fruit, since it must be mashed when freshly discharged from the steamer. It is essential to keep the fruit as hot as possible until it has been given the first pressing. The mortars and pestles are made locally by natives, who are entirely familiar with their uses. From one to three are necessary according to their capacity.

(*c*) *The hand screw-press** has been briefly described. The type illustrated in a previous publication has since been improved by cutting halfway through the cross head at one side, and fitting an easily operated screw lock to secure the head in position on one pillar. It is free to swing on the other pillar, and when the plunger has been screwed up so as just to clear the cage, the screw lock is

* Supplied by Messrs. Culley Expressors, Ltd., 46, Leadenhall Street, London, E.C.

slackened. The head, carrying the screw and plunger can then be swung to one side, thus enabling the cage to be readily charged with hot fruit or pericarp, and easily lifted out for discharging after the completion of the pressing.

As originally designed, the press cage rested on the cast iron base, and oil could only flow out through the small perforations in the walls of the cage. By fitting a perforated circular plate, separated from the base by bars of iron $\frac{1}{4}''$ thick, between the bottom of the cage and the base of the press, the flow of oil is facilitated and the pressure due to the descending plunger rendered much more effective.

When set up for use, the feet of the press must be firmly secured both to a rigid foundation and to the base of the press. The bolts provided for the latter purpose must be kept tight. The pillars supporting the cross head also require to be kept tightly screwed into the base casting.

The cage holds between thirty-six and forty pounds of mashed fruit, so that nine or ten charges of the first pressing are provided by one cooker full of fruit. The pericarp capacity of the cage is about forty pounds.

(*d*) The vessels used for collecting and purifying the oil are calabashes, bowls, empty petrol and kerosene tins, earthenware pots, etc. as normally employed by the native. It is essential that they be kept clean.

(*e*) A number of flat galvanised iron sheets are necessary on which to discharge the once pressed fruit for the separation of the nuts from the oily fibre. The surface on which this operation is carried out must be non-absorbent, non-corrodable, and readily cleaned. Galvanised iron appears to be the cheapest material available, and it has been found quite satisfactory in practice.

Arrangement of Apparatus.

Care should be taken when setting up the apparatus to ensure that the separate parts are arranged in the manner best conducive to facility of working. The cooker, mortars, and press, should be near to one another, so that the hot fruit has not to be carried more than a few feet from cooker to mortar, and from mortar to press. It is possible to arrange that the hot fruit from the cooker may be discharged direct to the mortar, if the latter is big enough to take two or three press charges at a time. In this case, the residue of mashed fruit should be covered to retain heat while waiting to transfer it to the press. The press may with advantage be erected under a shelter.

The Effect of Cooking the Palm Fruit.

The principal effects of steam cooking upon the fruit are:—(*a*) the softening of the oily pericarp, enabling the subsequent stages of the extraction to be carried on easily; (*b*) the destruction of the enzymes responsible for the development of free fatty acids in the "raw" fruit; and (*c*) the reduction of the moisture content of the pericarp. Of these, (*a*) and (*b*) have been discussed in previous publications; (*c*) has now been to some extent investigated because it was found that fruit boiled in a cauldron or earthenware pot, or steamed in a simple double-vessel cooker, did not behave satisfactorily during the expression stages of the extraction. This was found to be due to the physical condition of the pericarp.

With fruit steam cooked in the "Rapid" and "Pioneer" cookers, the first, and the early part of the second pressings yield palm oil containing very little water, and it is not until the later stages of the second pressing that the slimy emulsion of oil, water, and vegetable matter exudes in small quantities from the holes in the press cage. Fruit cooked in the double cooker yields an oil which is not so clear as that obtained by the former method, and with boiled fruit, the emulsion appears early in the first pressing, rendering the oil more troublesome to purify. The pericarp is in a more "slimy" condition, and often exudes in masses through the small space between the cage and press bottom, the former being lifted from its seating. When this happens the pressing must be stopped, as further pressure simply squeezes out the pericarp through the joint. A device whereby the press cage could be prevented from lifting would remedy part of the difficulty, but would not entirely overcome it, as the yields of oil from boiled fruit are lower than those from steamed fruit.

Examination of samples of fruit before and after cooking showed that the superiority of the "Rapid" and "Pioneer" cookers was due to the reduction of the moisture content of the pericarp during cooking. Results of a number of moisture determinations made on the pericarp of samples of fruit before and after cooking clearly indicate this, and are given below.

TABLE I.

Moisture Content of the Pericarp of Palm Fruit.

Samples taken from bulks of fruit before and after cooking.

No.	Mean Moisture Content of Pericarp Per Cent.		Difference.	Apparatus, and time of cooking.
	Uncooked.	Cooked.		
1	26·9	21·8	5·1	"Rapid" 65 minutes.
2	29·5	22·4 Upper portion	7·1	do. 1 hour.
		23·05 Middle portion	6·45	
3	28·7	25·3 Upper	3·4	do. 1 hour.
		25·6 Middle.	2·1	
4	28·5	22·1 Upper	6·4	do. 1 hour.
		21·3 Middle	7·2	
5	20·0	19·0	1·0	Double cooker 1 hour.
6	26·9	27·2	—	Fruits boiled in cauldron.
	In No. 6, the fruits were put into the water when it was already boiling. The efficiency of the extraction was 47·6.			

No similar determinations have been made on fruit cooked in the "Pioneer" cooker, but the extraction efficiencies with the two forms of cooker do not materially differ.

Cooker-Press Extractions,—methods of Working.

In the earlier extractions, the method adopted closely resembled that practised in certain parts of the Calabar Province. The fruit was cooked in a "Rapid" steamer, mashed by pestles in a wooden mortar, and the pericarp separated from the nuts by hand picking. The pericarp was then heated in a covered bucket in the steamer, and pressed twice in a "Culley" hand press. Between the pressings the pack of pericarp was loosened and reheated. The nuts, to which oil was still adhering, were washed with water in a pit, and the scum removed and heated to separate the oil. The results of No. 1 extraction in table II show that a not inconsiderable proportion of oil was recovered by washing the nuts. In Nos. 2, 3, 4 and 5 the quantity recovered from the nuts was less, a result attributed to more effective mashing and cleaner picking. The possibility of ultimately omitting the washing was indicated by No. 2. The necessity for loosening the pack before the second pressing was very evident, and in No. 5, the pericarp was beaten in the mortar before being heated for the second pressing. Washing failed to yield any more oil in this case, whereas in No. 2 a small quantity of oil was obtained in this way.

In No. 6 it will be remarked that the proportion of oil obtained by washing the nuts was again high, while the efficiency of the extraction was the lowest recorded. These results indicate that the mashing and picking were not well done.

It was concluded from these six extractions that the process was capable of improvement in the direction of (*a*) reducing the time required for the hand picking of the pericarp from the nuts, and (*b*) avoiding entirely the necessity for washing the nuts after picking. It was hoped that some simple and inexpensive method could be devised to facilitate the separation of oily pericarp from nuts in the third stage of the extraction, but though several expedients were tried, it was concluded that nothing short of a machine on the lines of the Culley depericarper would be effective. As such a machine would make the cost of the apparatus prohibitive to all but the wealthiest extracters of palm oil, and would moreover necessitate the monotonous turning of a handle for fairly long periods, its consideration was for the time being excluded from the investigation. Much of the tediousness of the operation of hand separation of pericarp from the nuts appeared to be due to the oily nature of the material, and it was thought that the removal of some of the oil by a first pressing of the hot mashed fruit would materially reduce the time taken for the picking. This was found to be the case. Not only was the picking facilitated, but the oil retained by the nuts was reduced to so small an amount that practically none was capable of being recovered by simple means. This amount was still further reduced by rubbing the roughly cleaned nuts on a coarse sieve, when adhering pericarp was removed, collected, and added to that already separated, (*vide* extractions 9 and 10).

The question of "dry" heating *versus* "steam" heating of the pericarp was investigated. In No. 7, the separated pericarp was heated in an oven, while in No. 8, as in all other extractions, it was heated in covered buckets inside the steam cooker. The difference between the results of Nos. 7 and 8 is in favour of steam heating under these conditions; but even if dry heating should be found to increase slightly the yield of oil, the cost of the fuel required would make the method uneconomical.

By allowing the mashed fruit to remain under pressure for a somewhat longer time, and taking care to heat the pericarp thoroughly for the second pressing, the quantity of oil obtained by a third pressing is almost negligible. An attempt to recover the highest possible amounts of oil by two pressings only was made in Nos. 9 and 10, and it is evident that some degree of success was achieved. The third pressing has, however, been retained as an

integral part of the standard process, since it enables one to make sure that as much oil as possible is recovered, and acts as a check on the care with which the earlier stages of the process have been carried out. When the natives who work the method have become sufficiently expert, it will be possible to omit this final pressing.

Standard Method.

The results of the investigations indicate that the following method is the most economical, and this has now been adopted as standard.

1. Cook the fruit in a Rapid or Pioneer cooker, for one and half hours after steam is first observed to blow from the top of the cooker.

2. Discharge the fruit in portions, and mash thoroughly, using wooden pestles. Do not allow the fruit to cool more than can be helped before proceeding with the expression.

3. Press the mashed fruit at once, gradually increasing the pressure to the maximum possible without cracking the nuts. Allow the mass to remain under this pressure for a few minutes.

4. Empty the contents of the press cage on to flat sheets of galvanised iron, and pick out the nuts from the pericarp. Clean them thoroughly by careful picking and rubbing on a coarse sieve, and add the pericarp thus removed to the bulk.

5. Heat the pericarp in a closed container within the cooker for twenty minutes.

6. Press the heated pericarp, increasing the pressure to the maximum possible by stages. Allow to remain under this pressure for a few minutes.

7. Beat the pericarp in the mortar, reheat and press again.

Treatment of oil.—Collect the oil from the first pressing, and the first runnings from the second pressing separately from the rest. Heat, allow to stand for a short time, and decant from water and dirt. The remainder of the oil should be boiled and skimmed.

The critical stages of the process are cooking and mashing. It is essential that the fruit be properly cooked. With insufficiently cooked fruit, the mashing does not satisfactorily strip the pericarp from the nuts, with the result that oil is retained on the surface of the nuts and lost. The mashing must be thorough and effective. Carelessness at this stage will materially affect the yield of oil by making the picking more difficult, and by reducing the efficiency of the press, since the oil will not have been thoroughly freed.

Quality of the Oil.

The oil from the first pressing (mashed fruit), and from the early stages of the second pressing (hot pericarp), is clear, bright, and almost free from water and dirt. The later runnings contain more water and foreign matter.

The variations in the free fatty acid content of the oil are interesting. Comparison of 1, 2, 3, 4, 5 and 6 with 7, 8, 9 and 10 shows that for similar periods between cutting and extraction, the F.F.A. of the oil is higher with the latter four. It is significant that the fruit which gave oils with the high F.F.A. content was separated from the bunches during wet weather. In many cases, considerable delay occurred between the times of cutting and extraction of the fruit. When this was reduced, the F.F.A. of the extracted oil was low, as may be seen by inspection of the results of Nos. 20, 21, 27 and 28. During the dry season, working under proper conditions, the F.F.A. of the oil obtained by this process should not exceed five per cent., and in the wet season, ten per cent. The lowest figure obtained for this value was 2·9 per cent., in a case where particular care was taken, and only a small quantity of fruit extracted.

Yields of oil and efficiency of the process.

In calculating the comparative figures for the yields of various extractions, a figure representing the percentage of the total oil present in the pericarp which has been extracted has been used. This value has been termed the "efficiency of extraction." It is a value which can better be used for comparing the results of extractions by different methods, or by the same process, than the one representing the percentage of oil to weight of fruit extracted. The latter varies very considerably, because of the variability in composition of the fruit according to degree of ripeness, season, and variety.

The mean efficiency of extraction in sixteen cases (Table III) is 63·5.

It may be considered that a process of this description should extract more than some sixty per cent. of the total oil present in the fruit, when present native methods, admittedly very wasteful, recover some forty-five per cent. to fifty per cent. By careful cleaning of the trays on which the picking is done, and ensuring that all sources of loss of oil during the preliminary stages of extraction are avoided as far as possible, one may conclude that the difference between the oil actually recovered, and the total amount originally present, is retained by the press cake, and on the surface of the nuts. With regard to the small amount (about six per cent. of the total) on the surface of the nuts, nothing can be done, except to see that they are cleaned as completely as possible. By utilising higher pressures, some of the oil left in the cake could be recovered ; but unless the hand press is considerably modified, and probably thus made more expensive, this is not possible. With the plunger and cage of the present size, and with the existing means of operating the press, it is not likely that a modification of the standard method of working would lead to increased yields. The press has already been improved by the provision of more outlets for the oil, and without radical alteration, the limit of efficiency appears to have been reached.

Inspection of the results of trials (Table II) will show that the proportion of oil extracted by successive pressings varies according to the proportion of pericarp to whole fruit. This is illustrated by Nos. 7, 8, 9 and 10. The greater the proportion of pericarp, the higher the pressure that can be exerted without breaking the nuts, and hence the greater the yield of oil at this stage.

TABLE II.

Results of Cooker—Press Extractions.

Date 1925.	Extraction.	Weight of fruit.	Method of extraction.	Yield.		% of fruit.	Composition of fruit per cent. P'cp.	Oil. P'cp.	Oil. fruit.	Efficiency of extraction.	Period cutting to extn. days.	F. F. A. of oil.	Remarks.
	No	lb.		lb.									
June 26	1.	296	Cook, mash, pick out nuts, heat pericarp, press, reheat, press. Nuts washed.	Pressings	34·15	11·53	—	—	—	—	2	3·78	—
				Nuts	4·62	1·56							
				Total ...	38·77	13·09							
June 29	2.	187·5	As above. Fibre washed after 2nd. pressing.	Pressings ...	22·0	11·72	—	—	—	—	—	—	—
				Nuts	2·2	1·17							
				Fibre	·38	·2							
				Total. ...	24·58	13·09							
June 30	3.	138	As 1.	2 Pressings ...	14·78	10·71	—	—	—	—	2	4·4	—
				3rd Pressing ...	1·45	1·05							
				Nuts	1·17	·85							
				Total ...	17·4	12·6							
July 6	4.	278	As 1.	2 Pressings ...	35·7	12·84	—	—	—	—	—	—	Machine extraction of similar fruit yielded 16·5% of oil.
				Nuts	2·3	·83							
				Total ...	38·0	13·67							
July 7	5.	250	As 1, but pericarp beaten after 1st. pressing.	2 Pressings ...	26·7	10·67	32·4	55·6	18·0	64	3	4·68	—
				Nuts	2·0	·8							
				Fibre washiug ...	nil	—							
				Total ...	28·7	11·47							
July 8	6.	250	As 5.	2 Pressings ...	29·1	11·64	43·2	55·5	23·9	56	4	6·4	—
				Nuts	4·1	1·64							
				Total ...	33·2	13·28							
Aug. 14	7.	298·9	Fruit pressed after mashing, before picking. Pericarp "dry" heated.	Pressing mashed fruit ...	16·81	5·63	38·3	53·2	20·4	63	3	9·5	Nuts more readily separated. Note low yield of oil from washing nuts.
				Pericarp 1 ...	17·25	5·77							
				do. 2 ...	4·1	1·37							
				Nuts	·5	·17							
				Total ...	38·76	12·94							
Aug. 15	8.	298·9	As above, but pericarp heated in covered bucket in steamer.	Mashed fruit ...	22·62	7·57	38·9	55·6	21·6	67	4	8·9	—
				Pericarp 1 ...	15·9	5·32							
				do. 2 ...	4·28	1·42							
				Nuts	·45	·15							
				Total ...	43·25	14·46							

Aug. 18	9.	298·5	As 8. Nuts rubbed on coarse sieve after picking.	Mashed fruit ...	16·25	5·44	34·4	57·5	19·8	59	—	10·9	Purchased fruit about ten days old.
				Pericarp 1 ...	18·0	6·03							
				do. 2 ...	·60	} ·28							
				Nuts	·25								
				Total ...	35·10	11·75							
Aug. 19	10.	143·9	As 9.	Mashed fruit ...	12·75	8·86	43·6	54·6	23·8	58	2	6·6	Nut washing unnecessary.
				Pericarp 1 ...	5·69	3·95							
				do. 2 ...	1·5	1·04							
				Nuts,—little muddy oil	—	—							
				Total ...	19·94	13·85							

TABLE III.

Extractions by "Standard" method.

Date.	Extraction number.	Weight of fruit lb.	Pericarp to fruit %	Yield of Oil.		* Efficiency of extraction.	Period between cutting and extraction days.	F.F.A. of oil as % palmitic acid.	Remarks.
				lb.	% of fruit.				
1925.									
August 27th ...	11	276·25	41·5	36·6	13·25	59	...	6·8	
September 7th ...	12	216·6	40	32·5	15·0	66	...	7·0	
„ 9th ...	13	348·4	35	39·31	11·28	62	8	12·5	
„ 24th ...	14	350	40·6	54·0	15·4	67	...	6·5	At Oloburo, Abeokuta Province.
„ 25th ...	15	350	...	45·0	12·85	68	...	8	
1926.									
February 3rd ...	16	615·3	30·5	67·4	11·0	68	...	...	
„ 8th ...	17	314·75	35·3	35·44	11·3	58	...	...	
„ 15th ...	18	592·4	33·0	69·1	11·7	64	...	...	
March 16th ...	19	300	37·3	36·25	12·1	59	...	...	
„ 18th ...	20	310·7	41·3	42·0	13·5	59	3	4·7	
„ 23rd ...	21	827	34·0	96·13	11·6	61	3	4·4	
„ 29th ...	22	388·9	37·0	51·63	13·3	65	...	...	
April 13th ...	23	300	46·6	48·0	16·0	62	6	7·2	
„ 14th ...	24	240	46·6	40·25	16·75	65	7	7·3	
„ 14th ...	25	300	...	45·13	15·0	...	6	6·9	
„ 15th ...	26	300	40·7	42·13	14·0	62	7	7·4	
„ 22nd ...	27	263	48·3	49·75	18·9	70	3	4·0	Mixed thick and thin shelled fruit.
„ 24th ...	28	296·25	...	39·81	13·4	...	2	5·0	

* Proportion extracted of total palm oil in the original fruit.

Some criticisms of the process.

The cooker-press method undoubtedly possesses a number of advantages over the present native methods for the preparation of palm oil. Among the more important of these are :—

1. The extraction is completed in a few hours. Two full cooker charges can be dealt with in a working day if sufficient labour is available for mashing and picking.

   In the soft oil process, the cooking is done on one day and the mashing and extraction on the day following. Four days are required to complete an extraction by the hard oil method.

2. The fruit is extracted while hot, and re-introduction of active fat-splitting enzymes is not possible until the oil has been cooled after the final clarification. If the hot oil is put into clean containers which can at once be closed, the possibility of later deterioration is reduced to a minimum.

3. The necessity for large quantities of fuel and water is avoided.

   The cooker requires little fuel, and heat may be conserved during the process by collecting the hot water from the cooker before discharging the fruit, and returning it ready for the heating of the pericarp.

   There is no "water extraction" as in the soft and hard oil methods.

   About four gallons of water are ample for the whole process of extraction of 350 pounds of fruit.

4. Less expenditure of actual energy is required to extract a given quantity of fruit by the press method than by the native methods. (This must not be confused with the number of persons and the time necessary to perform the extraction.)

5. Light employment is found for children.

6. The yields of oil are greater than with native processes, and the quality of the oil is superior to that usually prepared by the best native processes for export, both in the directions of freedom from water and dirt, and F.F.A. content.

The disadvantages of the method are:—

1. The number of people required to extract a given quantity of fruit is greater than with native processes. This is due to the speed with which an extraction is completed, and to the necessity for hand separation of the pericarp from the nuts in stage 4.

2. The method requires a higher degree of organisation of labour than is involved in ordinary native processes.

3. Imported apparatus, expensive from the point of view of the native, is necessary.

4. The separation of the nuts from the fibre is a tedious operation.

Reviewing these several points, and considering them in their relation to the problems of the native palm oil industry and to the investigations which have been described in former publications, it is concluded that without more highly organised labour, and imported apparatus, it is not possible to effect sufficiently marked improvements in primitive oil extraction processes. Thus, with the "soft" oil process, it has been shown that the quality of the oil may be improved by heating the water in which the fruit is to be cooked to boiling point before putting in the fruit. With the "hard" oil method, a modification has been described which results in the recovery of better oil. But these improvements are not sufficiently obvious to encourage the native to adopt them. When, however, as in the cooker-press process, a clear, bright oil is observed to run from the press, and a larger quantity than the native himself could obtain is recovered, the case is different.

At Oloburo, in the Abeokuta Province, where the process was demonstrated, the superiority of the steam cooker over the open pot method was at once realised by the natives. The press, however, did not appeal in the same way. It was admitted that more and better oil was obtained, but the women who normally extract the oil there said that the work involved in the final stages of the expression was too much for them. This cannot be admitted as a sound criticism of the process, the fact being that the native objects to comparatively severe exertion even for the few seconds necessary to effect proper pressing. Again, there is a natural aversion to the introduction of something quite new. The cooker was understandable, but the press was something entirely outside their previous experience.

In other districts, where the oil is extracted by wringing the pericarp after separation from the cooked fruit, it is hoped that the advantages of the press will be generally realised. The results of demonstrations now being carried on at Akpabuyo, Calabar, will thus be awaited with interest.

Now that palm oil is being purchased by traders on a basis of its F.F.A. content to an increasing extent, the introduction of a process whereby a high grade oil can be prepared will be encouraged. In the Lagos area, a premium is now paid by certain merchants for oil containing less than 15 per cent. F.F.A. calculated as palmitic acid. The difference between this figure and 18 per cent., the basis on which oil is sold on the Liverpool market, is to provide an allowance for deterioration during the voyage.

By careful clarification of oil from the new process, oils containing not more than 0·2 per cent. of water and only traces of dirt have been prepared, without using any apparatus apart from that described in this paper. In one instance, 8 gallons of oil prepared by this method, and purified by the De Laval purifier, was sent home to an important firm of consumers for examination. Their report was distinctly encouraging. The analytical data were:—

Oleic acids	...	4·4% (equivalent to 4% palmitic acid).
Water	...	0·2%
Dirt ...	...	traces.

As delivered by the purifier, the oil was entirely free from dirt. Traces were introduced by the tins in which the oil was shipped.

The comments on the quality and suitability of the oil for various purposes were:—

(*a*) The oil could be easily washed, presumably because of the absence of dirt.

(*b*) The bleaching trials were satisfactory.

(*c*) The oil, from the point of view of F.F.A., was better than most other descriptions of palm oil, except that obtained from Sumatra.

(*d*) A better yield of refined oil than usual might be expected (due to low F.F.A.)

(*e*) The oil had a good colour.

It is thus evident that the cooker-press method yields an oil superior to the usual Nigerian grades of oil, and this, coupled with the higher yields should recommend its adoption.

The question of instruction in the method should not be a troublesome one to deal with. Already a number of natives have become thoroughly familiar with the process at Moor Plantation, and four of them are capable of demonstrating it in the field. Two have already had experience in this connection.

The problem of the initial cost of the imported apparatus may, perhaps, be more difficult to overcome. It should be possible to obtain cookers and presses and issue them at a rental to native extractors of standing and intelligence who are prepared to use them to the limit of their capacity, or alternatively to make arrangements whereby they could be purchased on an instalment system. The actual returns to the oil maker in respect of the extraction of a given amount of fruit would be increased by 20 per cent. to 30 per cent. assuming that a premium were paid for oil of lower F.F.A. than 15 per cent. With the class of oil produced by the method, the premium would amount to 1·8 per cent. to 3·6 per cent. over the normal selling price to the trader. The balance is accounted for by the increased yields of oil.

The possibility of arranging to supply sets of apparatus to villages and communities for communal use should not be overlooked. In this case supervision would require to be exercised to ensure that the process was being properly worked, and that the plant was being used to as great an extent as possible.

The balance of evidence appears to be entirely in favour of the new process; and provided that the natural reluctance of the native to change his methods, and the difficulty of the cost of the necessary imported apparatus can be effectively overcome, it should recommend itself as the solution to some of the problems of the Nigerian Palm Oil industry.

Moor Plantation, Ibadan,

April, 1926.

AN INVESTIGATION OF SOME PROBLEMS OF THE NIGERIAN GROUNDNUT TRADE.

BY

A. C. BARNES, F.I.C., B.SC., A.M.I.CHEM.E.,

Agricultural Chemist.

I. INTRODUCTION.

Inspection of the published returns of exports of Nigerian products indicates that groundnuts rank high in the list of important agricultural products. Considering the fact that more than 90% of the groundnuts are collected and railed at Kano, the importance of the crop to the welfare of the large population of Northern Nigeria will readily be recognised. In addition to the tonnage exported, there is a large local consumption.

The whole of the crop is grown by natives, and the exported portion is prepared for sale and transported to the principal collecting centre, Kano, by native labour. The climate of Northern Nigeria is eminently suited to the production of groundnuts; but a discussion of the cultural methods practised is outside the scope of this paper, which is mainly concerned with a review of the condition of the marketed produce.

The investigations now to be described were primarily concerned with the condition of the produce marketed and exported during the very early part of the season 1925-26. A number of complaints were made by merchants in 1925 regarding the unsatisfactory condition of groundnuts offered for sale at the commencement of the 1924-25 season. Apparently, at this time, a fairly high price was offered at Kano by a few merchants, with the result that a quantity of immature and wet groundnuts were purchased and exported. On arrival in the country of consumption, the groundnuts were found to have undergone serious deterioration, and in some cases the sellers had to submit to arbitration which resulted in an allowance being made to buyers.

The Kano merchants appear to be strongly opposed as a body to early trading in groundnuts, though there are one or two firms which seem to have been tempted to indulge in early trading by securing remunerative contracts. Of some seventeen firms represented in Kano engaging in this trade, two have parent organisations which are actual " consumers;" *i.e.* manufacturers of groundnut products, while the members of the African and Eastern Trade Corporation and the Lever Group may be considered to represent mainly the " merchant " interest, though their parent bodies are to some extent also consumers. The " independent " firms, *i.e.*,

those outside these groups of companies are entirely interested from the " merchant " point of view, and as they comprise both English and Continental companies, it will be realised that there are a number of conflicting interests.

In addition to the European firms there is a number of non-European traders, who act chiefly as intermediaries between the native traders on the one hand and the European buyers on the other. These people, who are principally Syrians and Arabs, seem to be in a position to secure a very high proportion of the exportable crop at prices considerably lower than the market prices prevailing at any given time. They do not, as a rule, hold their stocks for more than a few days, nor do they export much on their own account; and it appears to be largely due to their influence that groundnuts are purchased in any quantity before the normal time of commencement of the " season."

During the season under review, one of these traders was buying as early as September, and by the middle of October was handling fair quantities of both undecorticated and decorticated nuts, whereas the European merchants,, except in one or two instances, were holding off until the beginning of November.

Native traders play an important part in the groundnut market. Many of them are employed by European firms, while others act independently, and sell the produce they secure to the highest bidder.

The prices paid by European firms do not as a rule differ very much and when variations of more than a few shillings per ton occur, they are usually caused by the early receipt of instructions regarding price alterations by firms whose representatives are in direct communication with their home offices. This naturally gives such firms an advantage over some of their competitors, as in the case of a falling market they can suspend operations, and with a rising one make heavy purchases, before the information of an alteration in price has become generally known.

II. Factors affecting the value of Groundnuts.

There are several factors which affect the value to a consumer of the groundnuts of Northern Nigeria, though some of them do not appear to have been hitherto appreciated at their true value. The more important of these are :—

(*a*) Oil content and free fatty acidity of the oil;
(*b*) Moisture content;
(*c*) Proportion of shell and dirt;
(*d*) Percentage of whole kernels in the mixture of whole and broken kernels, etc., resulting from the process of decortication;

(*e*) " Shrinkage,"—*i.e.*, loss in weight during storage in Kano;

(*f*) Gain in weight during transit from Kano to port of importation in Europe.

It is with these points that the investigations now to be described are principally concerned.

Methods of Examination.—Samples of decorticated groundnuts. *i.e.*, groundnut kernels ready for export were obtained from the native groundnut market, the Syrian trading quarter, and from European trading firms during October, November and December, 1925.

Every endeavour was made to ensure that each sample was representative of the bulk from which it was taken.

The following determinations were carried out in the order given :—

1. Sorting test.
2. " Shrinkage " Test,—loss in moisture on air-drying.
3. Residual moisture (on completion of 2).
4. Oil content.
5. Free fatty acidity of the oil.

1.—Sorting Test.—The object of this was to determine the proportion of whole, split, smashed or pulverised kernels, and shell and dirt in the sample A weight of 500 grams was used, and picked over by hand, care being taken to avoid any loss. The weight of each portion was then determined and the percentages calculated.

2.—" Shrinkage " Test.—A weight of 400 grams of the original sample was placed in a clean, dry, shallow tinware dish, exposed to the sun and air for several days, and weighed at intervals until no further loss was noted.

3.—Residual moisture.—A portion of the air dried material from 2 was ground in a mortar and the moisture determined on a weighed quantity by the usual method.

4 —*Oil content.*—A weighed amount of the ground material was extracted in a Soxhlet apparatus, using petroleum ether of boiling point 60°-80°C. as the solvent.

5.—The free fatty acidity of the oil was determined by the standard method on the oil obtained as above (4), the results being returned as per cent. oleic acid.

Experimental Data and Discussion of Results.

1.—Sorting Test.—Number of samples examined :—67.

Of these, four would be classed as " handpicked " and the remainder as samples of decorticated nuts (kernels) prepared by the usual methods.

Handpicked Samples.

	Whole kernels.	Split kernels.	Smashed or pulverised kernels.	Shell and dirt.
	%	%	%	%
1.	79·2	7·8	12·0	1·0
2.	76·6	13·2	8·6	1·6
3.	82·2	9·0	8·6	0·2
4.	87·2	6·8	5·2	0·8
Mean	81·3	9·2	8.6	0·9

Normal Samples.

Mean of 63 samples.	45·1	25·6	27·7	1·6
Highest	69.6	...	...	5·0
Lowest	29·6	...	...	0·6

The high proportion of damaged kernels is due to the primitive methods of decortication practised, whereby the groundnuts are beaten, usually in a wooden mortar with a wooden pestle, to break the shell and free the kernels. It is inevitable that many kernels should be broken in the process, but this is not the only drawback of the method. The mixture of shell and kernels is separated by winnowing, during which operation a not inconsiderable amount of finely pulverised meal is winnowed out with the shell, while varying amounts of shell, undecorticated nuts, and dirt find their way into the decorticated nuts, or kernels as they are better termed. The heaps of shell are favourite feeding grounds for goats, so that the loss of finely pulverised meal is more apparent than real; but the broken kernels, and shell and dirt present in the product decrease its value,—the former by exposing larger surfaces to the action of air and moisture, and such hydrolytic ferments as may obtain access to the mass and the latter because of their valueless nature.

The condition of the decorticated product explains why the oil expressed from it is inferior to that obtained from undecorticated nuts, and from " handpicked " decorticated nuts. Apart from the possibility of an increase in the free fatty acidity of the oil during storage and transit, which is greater in the case of broken than with whole kernels, the traces of free acid already present undergo further changes under the influence of air and moisture resulting in the formation of compounds having an objectionable smell and taste, thus giving rise to the condition known as " rancidity." These points will be discussed at greater length under their appropriate headings.

The proportion of shell and dirt observed in the samples exceeded 2.0% in 14 instances out of 67. Of these 14, three contained 5.0% 4.8% and 4.4% respectively, while the remaining 11 gave figures ranging from 2.1% to 2.8%. It is considered that

a shell and dirt content above 2.0% is excessive. The intentional adulteration of groundnut kernels is at times practised, though in the exceptional cases referred to above there was no evidence to show that the high shell and dirt content was other than accidental. The presence of sand and small stones accounted mainly for these high figures, the amount of shell present being normal.

It is a matter of considerable importance to exporters of groundnuts to ensure that their produce does not contain an unduly high proportion of valueless matter. During the height of the season it is not possible to examine each bag of groundnuts before export, with the result that in many cases the figure of 2% for shell and dirt is exceeded. Taking the Kano cost of the produce at £10 10s. per ton—a figure which obtained for some time during the current season—and the " all-in " marketing charges at £9 10s. per ton (including bagging, railing, shipment, and incidental charges), it will be seen that each 1% of foreign matter in excess of the allowed amount represents a loss of 4s. per ton to the merchant if the fact is discovered before sale, and slightly more to the consumer if it is not, including a waste to all parties of 2s. in carriage of valueless material. At the present time Nigerian groundnuts are not subject to any specific form of sale contract, such for example as that applied to palm kernels, though there appears to be a tacit understanding regarding the allowable content of shell and dirt.

2.—Shrinkage.—The loss in weight due to evaporation of moisture during the period of storage of the groundnuts is another point of considerable interest to merchants particularly during the early part of the season, when improperly dried kernels may be purchased. The climate of Northern Nigeria is exceptionally dry during the period November to April or May, and the loss of moisture from exposed wet or damp material is rapid. In the case of groundnuts, from six to nine days is sufficient to dry them thoroughly if they are properly exposed to the sun and air. In spite of this, much of the produce reaching Kano is still capable of losing weight due to evaporation of moisture when it is effectively exposed. The following data illustrate this point:—

Month; October, 1925. Number of samples examined ... 16

Mean shrinkage (loss in weight on air-drying) 6.6%

Maximum ... ... 12·2%

Minimum ... ... 0·8%

Shrinkage %	No. of samples.
12·0 to 12·2	3
9·0	1
7·0 to 8·5	4
5·0 to 5·5	2

10 or 62·5 % of all samples examined in October.

Month ; November, 1925.						No. of samples examined			...	54
Mean shrinkage	...	...	...	...	...	...	...	...	...	3·7%
Maximum	...	...	...	...	...	...	...	...	...	11·0%
Minimum	...	...	...	...	...	...	...	...	...	1·1%
8 samples or 14·8 % of the samples examined gave a shrinkage of 5·0 % and upwards.										
Month ; December, 1925.						No. of samples examined			...	7
Mean shrinkage	...	...	...	...	...	...	...	...	...	3·5%
Maximum	...	...	...	...	...	...	...	...	...	5·75%
Minimum	...	...	...	...	...	...	...	...	...	1·75%

Though occasional samples may exhibit a higher shrinkage, it is considered that under normal conditions 3 per cent. should represent the maximum, and that where higher figures are observed under the experimental conditions described it may be concluded that the kernels have been insufficiently dried. The figure of 3 per cent. would rarely be attained under trading conditions, as the kernels are stored in bags which are stacked in heaps in stores and in the open. Thus, the outer bags would lose weight if the contents were not thoroughly dried previously. The contention that groundnut kernels are capable of losing weight after purchase by merchants has been criticised on the grounds that by the time they reach Kano they are as dry as possible. The figures quoted demonstrate that as a rule the kernels are not fully dried at the time of purchase. Neglecting the figures obtained in October, it was observed that in all other cases comparatively high shrinkages were noted with samples of kernels freshly brought in from the "bush." The handlings to which they are subjected before being bagged and stored affords an opportunity for further drying, but in every case of kernels ready for export examined, shrinkage to some degree occurred.

Although 3 per cent. may be taken as a reasonable figure for the maximum shrinkage under trading conditions, it is hardly likely that 1% would be exceeded from this cause alone. Insects and rodents, and birds in the case of outside stacks are additional causes of loss.

One ton of bagged groundnuts stored in a corrugated iron building on a concrete floor lost 11 lb. weight, or 0.5% in thirty-one days. There was no evidence of damage by insects or rodents. Four samples of kernels taken from quantities purchased by the firm which carried out this test showed maximum shrinkages ranging from 1.1% to 3.0% with a mean of 2.5%.

The inadvisability of purchasing groundnuts very early in the season is indicated by the high shrinkages recorded in October with samples obtained from the groundnut market. In addition to the actual loss in weight which may be incurred with such nuts, there is the danger of deterioration of the wet material during storage and transit, which will be more fully dealt with in a later section.

Absorption of moisture from the air. During transit from Kano to the coast, the groundnut kernels are subjected to a change in atmospheric conditions which results in an actual gain in weight. As the coastal belt is approached the air is more humid, and the dry kernels absorb moisture. This effect would be more marked in a ship's hold, where the air is saturated with moisture, so that there is an appreciable gain in weight during the voyage home. It seems likely that the increase more than compensates for the loss due to shrinkage in Kano; but this fact does not help the merchant in Kano to explain a shortage, as the weights at the time of loading on rail are accepted by the shippers, and information regarding any appreciation in weight does not appear to be communicated to them by their head offices.

To test this point, twenty-three small bags, each containing from 5 to 9 pounds of thoroughly air-dried, whole groundnut kernels (*i.e.*, hand picked decorticated groundnuts) were weighed on January 5th, 1926, at Kano, put into a large bag, and taken to Ibadan. The bag was opened on January 25th and the individual bags again weighed. In every case an increase in weight was recorded, the figures ranging from 1.9% to 3.5% more than the original weights, with a mean of 2.7%. After another fifteen days a further increase in weight was observed, the average total gain being 3.6%. The highest figure recorded for the whole period was 4.7% and the lowest 2.8%.

3—Residual moisture.—Thirty-two samples were examined to determine the amount of moisture retained after thorough air-drying at Kano. The residual moisture was from 1.6% to 3.2%, the mean figure being 2.4%. It was observed that this value decreased during the period from November 19th to the close of the investigation early in January, the mean figure recorded during that time being 1.9%.

The total moisture, calculated from the loss in weight on air-drying and the residual moisture ranged between 14.7% for a wet sample and 3.7% for a dry one. The mean " total moisture " content of sixteen samples examined in October was 9.1%, and of sixteen samples during November and December, 5.2%. Of the thirty-two samples, eighteen from merchant firms gave a mean result of 5.1%.

4.—Oil content.—Satisfactory comparison of samples can only be achieved by calculating the oil content on the dry weight of the material. The oil was determined on the air-dried samples, and the percentage of oil to dry weight of kernels calculated from these results, and the residual moisture (*vide* 3 *supra*). Of thirty-two samples examined, the highest oil content thus calculated was 52.5%, and the lowest, 47.6%. The mean oil content calculated on dry weight was 50.0% for the total number of samples.

It is interesting to note that the figures obtained from samples collected during the very early part of the season (October) were generally slightly above the average, from which it is concluded that wetness, rather than immaturity of the groundnuts, is the danger attendant upon early trading. (cf. Shrinkage).

5.—Free fatty acidity.—The free fatty acidity of groundnuts is normally very low, unless they have been subjected to conditions which encourage the development of moulds, or allow fat-splitting ferments from other sources to gain access to the oil.

The values obtained by examination of thirty-two samples are given below :—

No. of samples.	F.F.A. as per cent. oleic acid.
1	3·0
1	2·6
1	2·5
12	1·0 to 1·6
16	less than 0·5
Lowest F.F.A. observed	0·2
Mean F.F.A. of 32 samples	0·95

The highest figure observed, 3.0%, was with oil from a wet sample of kernels containing 14.4% total moisture; but this alone would not account for the increase in F.F.A since other samples containing high percentages of moisture yielded oils with low free fatty acidity. The increase in F.F.A. in the oil of groundnuts, as with palm kernels, is due to the exposure of the produce to conditions which allow fat-splitting ferments to obtain access to the oil. The groundnuts themselves do not contain a ferment, or enzyme, capable of acting on the oil and generating free fatty acids. Wet groundnuts, when stored in a confined space, will heat and ferment. Fungi, which secrete fat-splitting ferments, develop under these conditions, the oil is hydrolysed, and the free fatty acidity increases.

Naturally wet, and artificially wetted groundnuts, *i.e.*, those which have once been dried and then soaked, behaved similarly in this respect as shown by the following experimental data.

(*a*) Whole kernels from nuts decorticated immediately after harvesting were placed in a covered dish and left for one month. In a few days the kernels were covered with a growth of moulds

Moisture content of the wet kernels	35%
F.F.A. of the oil extracted at the end of the period (as oleic acid)	32.4%
F.F.A. of the oil from a similar sample of kernels air-dried immediately after decortication	0.2%

(*b*) A different sample of kernels treated in the same manner as (*a*).

Moisture content of wet kernels 28%
F.F.A. of the oil extracted at the end of the period 29.9%

(*c*) A quantity of air-dried decorticated nuts (kernels) from a merchant firm was soaked with water, left overnight, thoroughly mixed and sampled, and placed in a box which was covered with empty bags. A thermometer was inserted into the mass of kernels, and the temperature read at intervals. After 23 days, the box was opened and the contents examined. Moulds had developed in quantity, and the kernels possessed an unpleasant smell.

Original sample:—

Total moisture 6.4%
Oil : dry material 49.7%
F.F.A. of extracted oil as oleic acid 0.3%

Sorting test—

Whole kernels 37.6%
Split kernels 30.6%
Pulverised kernels 29.6%
Shell and dirt 2.2%

Wetted material:—

Total moisture 13.8%
F.F.A. of oil extracted after 23 days 22.8%
Increase in F.F.A. 22.5%

The oil was of a dark brown colour and possessed an objectionable smell.

Maximum temperature recorded 52.0°C. in 6 days from start of experiment.

Maximum rise in temperature 28.0°C.

(*d*) Another sample similar to (*c*) was wetted and kept for 23 days.

In this case less mould than in (*c*) was observed.

Total moisture 12.9%
Increase in F.F.A. 6.6%

The oil was of a bright yellow colour.

The serious deterioration of the produce resulting from the bagging, storage and shipment of wet groundnuts is quite evident from these results. The oil is rendered objectionable from two points of view,—the increased free fatty acidity, and the subsequent development of rancidity. Not only is the value of the oil reduced,

but it is rendered practically useless for the preparation of edible products, and the residue from the expression of the kernels, generally utilised as cattle food, becomes unsuitable for this purpose.

Another point of interest in connection with groundnut oil is indicated by the free fatty acidities of oils extracted from kernels obtained in different ways and stored under varying conditions. Four samples have been examined in the following manner:—

(*e*) A portion of the bulk from which the sample (*c*) above was obtained, was taken to Ibadan and kept for three months. It was used for the observation of increase of weight of Kano-dried kernels in a humid climate described on page 56. On March 27th, 1926, the oil from several pounds of this was cold drawn in a small hydraulic press under a pressure of 2 tons per sq. inch. The oil was heated and filtered, and its free fatty acidity determined.

(*f*) A quantity of handpicked kernels from nuts grown on Plot 55, Block K, Kano farm, lifted in November and December, 1925, and kept at Ibadan under similar conditions, was expressed and the oil treated as described above.

(*g*) and (*h*) On March 29th, 1926, a bulk of 40 pounds of groundnut kernels, decorticated by native methods, and containing a normal proportion of broken kernels and shell, was received from Kano. This was sorted into whole and broken kernels, and the latter were sieved to remove fine sand and the smallest particles of broken material. The whole kernels (*g*), and the sieved broken kernels (*h*) were separately expressed, and the two samples of oil treated as before.

In no case was the husk removed before expression.

The free acidities expressed as per cent. oleic acid are given below.

	F.F.A. in Jan.	F.F.A. in March.		Colour of oil.
(*e*) Commercial sample	0·3%	3·9%	Kept at Ibadan.	Deep yellow.
(*f*) Handpicked ...	0·9%	1·0%	„ „ „	Pale yellow.
(*g*) Whole kernels ...	...	0·3%	„ „ Kano.	Yellow.
(*h*) Broken kernels ...	...	0·5%	„ „ „	Pale yellow.

These results afford a further indication of the better keeping qualities of whole kernels as compared with the mixture as now exported, and show that with the air-dried material in Kano, the oil expressed from the whole kernels is slightly superior to that from the broken portion obtained from the same bulk.

III.—The Control of the Quality of Groundnuts for Export.

There can be no doubt that the complaints made regarding the condition of the groundnuts shipped during the early part of the season 1924-25 were caused in the manner just described, and it is evident that every care should be taken by merchants and others interested in this trade to avoid a recurrence of the trouble.

Immature groundnut kernels may be dried and stored without any serious deterioration; but the wet produce, whether immature or mature, will deteriorate unless it is dried before being bagged ready for export. The onus of blame for the deterioration of quality due to wetness lies on the purchaser rather than on the vendor. If inducement, in the form of a high price, is offered at the beginning of a season, the native growers and traders will supply produce which is insufficiently dried. The Kano merchants who purchase such produce will bag and export it without delay in order to take advantage of the availability of rail transport to the coast, which later in the season is inadequate to keep pace with the rate of supply of the groundnuts to Kano. It is fully realised that these merchants act under instructions from their headquarters, and that in many cases they have little discretionary power in a matter of this description. Most of them are reluctant to enter the market until after November 1st in a normal season; but a few do, and all are liable to be supplied with inferior produce purchased at a very early stage of the season by the non-European traders to whom reference has already been made. So long as this is really dry, little harm is done to anyone except the grower, who has been tempted to lift his crop before it is fully ripe, whereby his return for a given planted area is reduced; but if it is wet then the purchaser should either insist on its being dried before delivery, or dry it himself prior to export.

A "Close Season" for Trading in Groundnuts.

A suggestion has been made that trading in groundnuts should be prohibited by law before a certain date in any season. Theoretically, this may appear to afford a solution of the problem, but its practical application would present many difficulties, and might not entirely avoid the trouble it was designed to prevent. It is significant that a regulation to this effect has been withdrawn in one of the French West African colonies, presumably because it did not work satisfactorily, though the reason given for its repeal was illegality! In Northern Nigeria the normal time of harvesting the crop depends on the date of cessation of the rains. Usually the groundnuts are allowed to remain in the ground for about six weeks after the last rain. This would mean that a definite date for trading to commence could not be fixed until the crop was nearing maturity.

The introduction of a hard and fast regulation would undoubtedly operate harshly on some sections of the native community, since even if their crops were ripe and harvested, they would be unable legally to sell and so secure cash, which they might need, until the scheduled date. The natives' need of money in many instances, would provide opportunities for unscrupulous native traders to advance money on account of a lifted crop, and defer taking delivery until the sanctioned time. For this convenience the grower would have to pay. It would be a matter of considerable expense and difficulty to check such practices, and even if they were prevented, the danger of wet groundnuts coming into the Kano market would not be entirely overcome.

Experiments carried out with groundnuts from plots at the Kano Agricultural Experiment Station (*vide* page 64) show that the crop still contains a high percentage of moisture when lifted at the end of November, and that a week is required to secure thorough drying after harvesting. If, therefore, for any reason groundnuts harvested at the proper time, usually late in October or early in November, were not effectively exposed before and after decortication in order to dry them properly, there would still be the possibility of deterioration during storage and transit.

It would thus appear more satisfactory to rely, if this were possible, on the good sense of producer and merchant to sell and purchase only properly prepared nuts, rather than to introduce legislation in an attempt, probably unsatisfactory, and certainly irksome, to achieve the same end by making trading illegal before a specified date.

One doubts whether the fault lies with the actual producer in cases of the sale of improperly dried produce. He can hardly be blamed for disposing of his crop if he is satisfied with the price offered, whatever its condition. The intermediate native traders will naturally endeavour to avoid loss caused by shrinkage either by disposing of their produce quickly, or as is occasionally done, by wetting it to increase its weight and risking discovery.

The Case for Inspection and Grading of Groundnuts.

Since wetness, and not immaturity alone, is the cause of trouble, the sale, or export from Kano or other collecting centre, of groundnuts containing more than a specified amount of moisture might be prohibited, and such cases as were detected penalised, if it were not for the fact that punitive methods would be difficult of application and might not achieve their object.

The merchant naturally makes every endeavour to ensure that the produce he purchases is dry, in order to minimise his store losses, and it can hardly be said that he unwittingly buys wet groundnuts.

Such produce is usually easily noticed, and spread out for drying before being bagged, as may often be observed at groundnut buying stations. Competition is very keen in the Kano groundnut trade, and each firm appears to be instructed by its head office to purchase a definite tonnage in a season, the quantity being based on the total estimated crop available for export. Thus, he may knowingly purchase produce below standard in order to carry out his instructions regarding total purchases, and to keep "in the market." Each firm appears to have its own customers on whom reliance is placed for supplies, but if for any reason a consignment is refused, the merchant may lose one or more of his customers by their transferring their trade to another firm. Hence, from several points of view, it appears preferable to control the quality of the produce rather than the period when trading in it shall be carried on, in order to avoid interfering more than necessary with the freedom of the trade.

From this review of the case, it is concluded that the establishment of authorised markets, on the lines of the cotton markets, where the produce could be inspected and graded, would most satisfactorily meet the requirements of the trade. Such markets would need to be situated in the growing areas, where the produce could be inspected before transit to the main collecting centre. In this way, the possibility of deterioration during transit to Kano from a distant district, which exists under present conditions, would be almost entirely avoided. Adulteration would be actively discouraged, the decline in the quality of the produce from year to year remarked upon by merchants, and caused by careless decortication, would immediately be checked, and improvement encouraged.

Opposition to the introduction of an inspection and grading scheme would doubtless be shown by a section of the non-European trading community; but European merchants would probably appreciate its advantages, and co-operate in the preliminary discussions of ways and means to be adopted to secure the most satisfactory working and later, in the organisation and operation of the markets.

The inspection would be directed to the detection of (*a*) wet kernels, and (*b*) parcels containing more than a specified proportion of shell and dirt. Grading according to the content of whole kernels might be included. This work would easily be performed by natives under European supervision, after a short period of training.

It is not a difficult matter to tell whether groundnuts are satisfactorily dry. Wet groundnut kernels, *i.e.*, those containing 10% or more of moisture, yield to the pressure of the fingers like a

firm jelly, and do not break with the crisp snap characteristic of dry ones. Before fracturing, they bend somewhat, as may readily be observed with the split portions of wet kernels. The husk does not separate readily, and if stored for a short time in a closed space, the kernels become discoloured and develop an unpleasant smell.

In cases where wet kernels were detected, an order to dry them for a few days before submitting them for grading would have to be given and carried out. On being satisfied as to the dryness of a parcel, the inspector would decide whether it was satisfactorily free from shell and dirt, and then proceed to grade it according to predetermined standards. Comparison with specially prepared standard samples would be adequate for this purpose. In many cases, cursory inspection is sufficient to decide whether a parcel is of average, poor or fine quality; but the use of standards would always be advisable.

To devise such standards is a simple matter. Observations of the results of a number of decortications by the usual method would have to be made, and a standard for " average " quality based on them. This might be termed " Grade I ". " Grade II " would then include all parcels inferior to the standard, and there might be a " Special Grade " for parcels of particularly good quality, such as those now locally termed " hand-picked."

Inspectors would be given authority to reject, or place in a third grade all parcels containing an exceptionally high proportion of shell and dirt. Small amounts of shell are not objectionable, but sand and dirt are, and every endeavour should be made to avoid their presence in exported produce. Here, again, it is a simple matter to devise a method of examination which would be rapid and reliable.

The advantages of such a system of inspection and grading should merit the approval and support of the merchant community. The difficulty of attempting under existing conditions to examine every consignment purchased in the busy period of the season has already been referred to. Inspection would avoid the inadvertent export of produce containing a high proportion of foreign matter, the possibility of deterioration of the kernels would be evaded, and store losses caused by shrinkage reduced.

The existing groundnut market at Kano falls far short of the requirements of the trade. Buying stations are still dotted all over the merchant quarter in trading compounds, and in some instances firms do not use the market at all. No control over the quality of the produce is exercised, with the result that good and bad parcels are indiscriminately mixed. The conditions under which trading is carried on are such that accidental or intentional addition of sand and dirt to the kernels is easy, and bribery is rife.

Moreover, the merchant has to a great extent lost contact with the producer. In the early part of the season, at any rate, many tons of groundnuts come into the market in an unsatisfactory condition, a state of affairs which would be remedied by inspection nearer the source of supply.

The feeling of reliance on the quality of the produce engendered by proper inspection and grading would go far to lighten the burden of responsibility of merchants in Kano, and the frequent reports from home of " bad out-turn," often resulting in arbitration and loss to the seller would be entirely avoided. The argument is thus overwhelmingly in favour of inspection and grading of groundnuts, and the early introduction of a scheme directed to this purpose is recommended.

IV.—Other Experimental Work.

In addition to the experiments described in an earlier section (pp. 52 *et seq.*) a series of observations was made on the groundnuts grown at the Kano Experimental Farm of the Agricultural Department, Plot 57, block K, consisting of ninety-three rows sown with the local (Kano) variety, was selected, and the scheme of work detailed below decided upon. Three methods of harvesting recommended by Mr. Hewitt, Superintendent of Agriculture, were adopted, and rows were lifted at intervals in different parts of the plot in this manner :—

(*a*) Haulms lifted, turned, and left to dry for three days. The nuts were then stripped, and left on the ground for a further three days.

(*b*) Haulms lifted, nuts stripped at once, and left on the ground for three days.

(*c*) Haulms lifted, nuts stripped and collected immediately for examination.

In each case the nuts were cleaned from earth and stalks after collection, and weighed. 500 grams were taken for hand decortication, and another weighed quantity was air-dried. The kernels from the decorticated portion were weighed and air-dried.

On completion of the air-drying of the undecorticated portion, the kernels were separated by hand, weighed, and exposed to sun and air, and further loss in weight, if any, determined. The residual moisture, oil, and free fatty acidity of the oil were determined on as many samples as possible.

Owing to an error, the remaining rows of plot 57 were lifted some three weeks before the intended date for the conclusion of the experiment, and plot 55, block K was utilised for later work, which was carried on along similar lines until December 24th.

From these experiments a number of broad conclusions have been drawn. It is not possible to arrive at definite statements on a number of points, more particularly the increase in oil content

with maturity, because of the facts that the crop was planted rather later than the normal time, and the experiment could not be carried to its projected conclusion for the reason given above.

Considerable differences were noted between the portions of the crop obtained from the lower and upper parts of the plot (57). The reason for this was not evident from the cursory inspection possible, and since the plot had not been kept under special observation during the whole period of growth, no explanation can be given. The conditions under which the work had, of necessity, to be carried on rendered it impossible to make other than cursory observations of the incidence of disease in the plants, and insect attack of the crop,—factors which must materially affect the yield. It is suggested that future work should be undertaken in order to obtain data regarding these matters.

It will thus be realised that the application of corrections to the recorded observations is not possible in the present instance.

Discussion of Observations.—This portion of the investigation was primarily undertaken to elucidate some of the factors adversely affecting the early lifting and sale of the crop, so that the results will mainly be reviewed from this aspect. The principal cause of deterioration of the crop after harvesting has been shown to be the presence of excessive moisture in the kernels when they are bagged and stored. (p. 54). From the results of observations already discussed it will be seen that it is important to dry the groundnuts as rapidly as possible. When spread in thin layers on the ground, the nuts are satisfactorily dried in seven days from the time of lifting the haulms. The kernels still contain a little moisture capable of being lost on exposure to the air and sun, but this rarely exceeds 3%.

Later in the season, the time required to air-dry the nuts was reduced to about five days, and for very late harvesting an even shorter time was sufficient. This effect is due to the loss of water as the crop matures in the ground. The loss in weight on air-drying of nuts collected at the time of lifting (method C), three days after lifting (method B), and of the kernels from freshly lifted nuts is shown by the following figures :—

	Mean loss of weight per cent.		
Date of lifting.	Nuts (method b).	Nuts (method c).	Kernels (method c).
October 26th	28·5	53	50·5
November 5th	19·5	51	45·3
14th	10·7	46·4	44·6
21st	8·8	42	38·8
28th	...	27·8	29·1
December 4th	6·1	25·3	26·3
11th	2·7	19·5	17·8
18th	1·8	12·1	10·1

A gradual increase in the proportion of kernels to nuts decorticated immediately after lifting the haulms was observed until December 4th, after which a marked fall occurred, caused by white ants attacking the kernels while in the ground. The kernels from the nuts lifted during the earlier stages of the work were of a pale colour, and very soft and wet when fresh. On drying they shrivelled, and the surface exhibited a wrinkled appearance. The nuts themselves were pale green in colour.

Kernels loose in the shell at the time of harvesting were first observed on December 4th.

As the crop matured the proportion of shrivelled kernels after drying decreased, and the average weight of the kernels increased regularly from 0.24 gram on October 26th to 0.33 gram on December 18th. The average weight of ripe kernels was 0.40 gram.

The oil content of the moisture free kernels showed some variation, figures ranging from 40.8% for the harvesting of October 26th to 47.6% on November 14th, being recorded. The mean oil content of nineteen samples of kernels from nuts lifted between October 26th and November 28th was 45.2%, calculated on the moisture free material. Of these, seventeen contained more than 44% of oil. No relation could be traced of any marked increase in oil content, calculated on the dry weight of material with maturity, though there was a fairly regular increase in oil content to wet weight with time. It is noteworthy that the mean oil content observed in this case was 4.8% lower than that of thirty-two samples taken from other sources during the same period.

The free fatty acidity of the oil from the air-dried kernels was low in most cases. The highest figure observed was 2.7% for nuts lifted on November 11th. There was evidence of insect attack on the kernels, some of which were damaged and discoloured. The mean free fatty acidity of the oil from nineteen samples was 0.7%, calculated as oleic acid. Again, no relation between free fatty acidity and maturity was observed.

The proportion of kernels to air-dried nuts increased as the crop matured, the mean figures ranging from 55.3% to 67.8% (observed with nuts lifted on December 11th). The lowest individual figure was 46.4%, and the highest, 72.8%. In eleven other individual rows, the proportion of kernels to air-dried nuts was 70% or more in December. The corresponding figures for nuts lifted on December 18th showed a marked falling off, a fact caused by the increase of attack by white ants.

The evidence of an increase in the weight of kernels after lifting the haulms and leaving them with nuts attached for three days, and of an increase in the proportion of kernels to air-dried nuts under similar conditions, *i.e.*, of maturing after lifting, was inconclusive, though figures indicating the possibility of this were obtained. No definite statement can be made on this point until further inquiries have been instituted.

Two samples of immature kernels from nuts lifted on the 5th and 14th November, 1925, were examined for the F.F.A. content of the oil on February 22nd, 1926. Though small increases in F.F.A. were recorded, the figures obtained, which were 1.2% and 0.75% respectively, were still very low. The characteristic smell, reminiscent of milk fresh from the cow, observed with crushed immature kernels soon after harvesting, was still evident.

The main facts emerging from this brief consideration of the investigation are:—

(1) The crop when lifted in an immature condition gives a lower return to the producer than if left in the ground until mature.

(2) Immature groundnut kernels shrivel when dried, and the surface exhibits a wrinkled appearance. The dry kernels are small and of low average weight.

(3) The oil of immature groundnut kernels is low in free fatty acidity. The proportion of oil in the dry immature kernels is not markedly lower than that in mature kernels of the same variety.

(4) Thoroughly dry immature groundnut kernels do not deteriorate on keeping.

V.—*The preparation of Groundnuts for Export.

From the review in section II of this paper of the general condition of groundnuts intended for export, it will be realised that there is room for improvement. The presence of broken and pulverised kernels, shell and dirt, reduce considerably the value of the produce to the consumer, and result in a lower return to the producer than would be secured by the introduction of more careful methods of preparation. Comparison of normal and " handpicked " samples shows that the native can turn out a high grade product if he wishes. The demand for groundnuts, and the conditions under which the trade is carried on, appear to encourage less

* A report on this subject was submitted to the Director of Agriculture on December 17th, 1925.

careful methods of preparation, since bulk rather than quality is the general policy of the merchants. Much as they might wish individually to improve the quality of their produce, the combined action necessary to secure this end is at present lacking.

It has not been possible in the time available to find out the true market definition of " hand-picked decorticated " groundnuts, though it is assumed that parcels of mature whole kernels, free from shell and foreign matter, fall within this category. Market quotations for this class of groundnuts are from 20% to 50% higher than those for decorticated Nigerian groundnuts. Whether such a high premium as 20% could be obtained for " hand-picked Nigerian " is a matter regarding which inquiries have been instituted, but there is every likelihood that a sufficiently enhanced price would be paid by consumers to make the more careful preparation of the produce worth while.

This matter is governed to a considerable extent by the grade of raw material suited to the preparation of edible oils for the margarine and " salad oil " industries. Undecorticated groundnuts are preferred, and decortication is usually effected at the crushing mill prior to the expression of oil from the kernels. There is, however, reason to believe that if Nigerian groundnuts were so prepared that they contained but a small percentage of damaged kernels, and no shell and dirt, and were thoroughly air-dried before export, they would be suitable for the preparation of edible oil to a greater extent than at present, and would command a higher price, provided that they were expeditiously transported from Nigeria to Europe. In the case of dry groundnuts the action of air and moisture on the traces of free fatty acids in the oil gives rise to the condition known as rancidity, which renders the produce less valuable. The presence of a high proportion of damaged kernels, as in Nigerian groundnuts, causes this effect to be much more marked. If the kernels were whole, they would be protected by husk, a much smaller surface would be exposed to the action of air and moisture, and a longer exposure would be necessary to give rise to the trouble.

There are three possible methods whereby the desired improvement in the quality of the exported crop may be achieved. They are :—

(*a*) Shipment in the undecorticated condition.

(*b*) Improved methods of decortication locally.

(*c*) Cleaning and grading of the decorticated nuts before export.

Two of these, improved decortication, and cleaning and grading would be likely to result in the payment of a somewhat higher price to the native grower than is offered under present circumstances for any given condition of the European groundnut market, and so encourage the planting of larger areas.

In considering the relative merits of these methods, it must be borne in mind that the main crop has to be carried over 700 miles of railway to the coast for shipment, and that a high proportion of it is transported to Kano, the principal collecting centre, by camels, oxen and donkeys. This point must materially affect the consideration of the proposal to bale undecorticated nuts and ship them in this condition, in that transport costs would have to be paid on the valueless shell, which forms 30% of the total weight of the nuts. Not only would inland transport costs be increased, but the amount of produce which could be brought in by the present available means of transport would be limited. Screening would be necessary to remove dirt and empty shells before baling.

It may thus be concluded that the cost of baling, railway transport and shipment of undecorticated nuts would reduce the value of the crop to the grower below its present level relative to the groundnuts produced in other countries, in spite of the fact that undecorticated groundnuts are preferred to the decorticated variety for the preparation of high class edible oil. Apart from the economic aspect of this problem, the practical difficulties of baling the nuts and shipping them in this condition are such as definitely to discourage any efforts to introduce such a system. It has been found that the bales must be enclosed in strong material in order to avoid loss, and that the pressure exerted on the material during baling must be controlled with great care. It will thus be inferred that baling is out of the question in the case of groundnuts from Northern Nigeria.

Turning to improved methods of decortication, there appear to be three possibilities; (1) improvements in native methods involving the use of none but the simplest apparatus; (2) the introduction of hand driven decorticating machines, and (3) the establishment of power driven decorticating plants of large capacity in selected districts convenient to the actual producing areas. Of these, power operated plants appear to be most promising, though hand driven machines might find limited application.

For mechanical decortication to be successful, it would be necessary to secure the co-operation of trading firms in the establishment of the plants. It is not suggested that they should be confined

to Kano, though that would probably be the centre decided upon for the crop grown within a radius of, say, fifteen miles. The fuel for power-raising would be provided by the waste shell.

The mechanically decorticated nuts would be screened to remove dirt, and might be graded by further screening into whole and broken kernels. The cost of mechanical decortication would be expected to be much lower than that of the hand methods now practised, and this, combined with the absence of shell and dirt, and of a high percentage of broken kernels, should result in a greater return to the producer provided he does not have to carry his unshelled nuts very far.

The grading into whole and broken kernels might be applied with advantage to groundnuts as now prepared for export, provided that the enhanced value of the high grade product thus separated rendered the process a paying one. This point depends on the relative values of whole kernels, free from shell and dirt, Nigerian groundnut kernels as now exported, and broken and pulverised kernels separated from the mixture by screening.

The success attendant upon any improvement in the general condition of the produce, having for its object an increase in value, would largely depend on the availability of rapid and efficient transport to the country of consumption, and on the provision of proper storage facilities at Kano and the port of shipment. As things are, it is only at the beginning of the season that the railway can cope with the tonnage of groundnuts to be exported, so that as the quantities coming into Kano increase above the rate at which the railway can handle them, storage for the surplus is necessary. In this way, large amounts accumulate and are stored in bags both under cover and in the open for periods amounting to three or four months. During this time losses occur through the action of grain beetles and rodents and in the case of stacks, birds cause additional damage. These losses would be avoided if the groundnuts were stored in large bins (silos), without being bagged. Thus, it would be possible to treat the produce with a powerful insecticide, such as carbon disulphide, which would effectively prevent the serious damage now caused by the action of beetles. Such bins would be so arranged that they could be closed at the top and at the bottom, so that other pests would be entirely excluded.

By combining bulk storage on these lines with bulk transport by rail and steamer, it appears that considerable savings in handling and transport costs would be effected.

The cost of marketing groundnuts from Northern Nigeria, including bagging, railing, shipment and all charges amounts to £9 10s. 0d. per ton. Of this amount £1 4s. 0d. is represented by the cost of bags, twine, and labour in filling and loading. At the prices now ruling in England and on the Continent, the rail charges and duty amount to one-quarter of the value of the produce. Any scheme, therefore, which is directed to the cheapening of the cost of marketing is worthy of careful consideration.

Groundnuts lend themselves readily to transport in bulk, and the quantity exported annually would seem to be sufficient to justify the expenditure necessary for loading plant at Kano, modifications to rolling stock on the railway, and facilities at the port. Existing stores near the railway sidings at Kano could be adapted without much difficulty. Assuming that the actual handling charges remained at their present level (though they would probably be reduced), the cost of bagging, amounting to upwards of £1 per ton would be saved. This would not be the only advantage. More expeditious handling and loading both on rail and on steamer would be secured, and the time between purchase at Kano and receipt by the consumer reduced, so that the chances of deterioration of the produce would be decreased.

The introduction of bulk handling would, however, be inadvisable unless a system of inspection and grading was practised. Without this, the inevitable mixing of high and low grade groundnuts in a shipment would adversely affect its value, and the object of the method would be defeated. By previously grading the produce, it would be possible to ensure that each shipment was of uniform and standard quality, a state of affairs which would be appreciated by all concerned in the trade.

Moor Plantation,
March, 1926.

A NOTE ON THE IMPROVEMENT OF AMERICAN COTTON IN NORTHERN NIGERIA.

BY

J. K. MAYO, B.A.

This work was begun in 1923 with the selection of nineteen superior plants by sowing the seed in progeny rows of fifty-one plants, and selfing the flowers. The following characters were determined for each plant.

Mean maximum lint length.
Lint index.
Weight of lint, per boll.
Ginning %.
Seed weight.

An account of this first season's work was published in this Bulletin in 1924. (1)

The same procedure was followed in 1924 using fifteen plants selected from the progeny rows, and again in 1925 using nine selfed selections and five 'new' selections from the field. Some other varieties were grown, of which Hartsville promises well, being similar to Allen in most respects but more vigorous and probably more productive.

1925 PROGENY ROWS.

1. *Lint Characters.*—Lint length, etc., was determined for each plant, and the means for the various strains are tabulated below. The nine superior plants selected in 1925 included four pairs of 'sister' plants (sister plants are plants produced from one parent plant). The progenies of sister plants are bracketed together. As might be expected after inbreeding there is some correspondence in these pairs but it is by no means complete except perhaps in strains 6 and 7. For instance the differences in lint length and lint index between strains 8 and 9 are too great to be accounted for by experimental errors.

Unfortunately all records made previous to November, 1925, were destroyed by fire, with the exception of the mean lint length, etc. of the 1923 plants and the characters of the plants selected in 1925. These have been included in the tables for the sake of comparison.

Selection has been directed mainly with a view to increasing lint length, ginning percentage, and yield, and it is evident that as far as the first two are concerned considerable progress has been

made. Yield has not been improved directly but characters which are correlated positively with yield such as lint index and weight of lint per boll have higher values in 1925 than they had in 1923. The high values recorded for lint per boll in 1924 may be ascribed to an unsatisfactory method of counting the bolls.

It seems rather doubtful whether a strain of Allen cotton can be grown in Northern Nigeria to yield a longer staple than 35 mm. (mean maximum), though single plants are commonly found with longer lint. Out of fourteen selections only two progenies gave higher values than their parents. Moreover lint length will very probably be depressed when the plants are grown by native farmers.

'*Strength*.'—In previous years this was estimated by breaking a small bundle of fibres with the fingers. It was neglected this year as the method did not seem sufficiently accurate and no other method was practicable.

Variability.—The coefficients of variability are generally lower than those of 1923. Much of this reduction is undoubtedly due to inbreeding, though improvements in method, especially in the measurement of lint length, may be partly responsible.

2. *Vegetative characters*.—As was to be expected sister plants gave progenies whose vegetative characters were clearly very similar, and distinct from the other progenies. Strain 3 made poorer growth and shed its foliage sooner than the other strains. It was the only strain with naked seeds. Strains 1 and 9 germinated so poorly and were so difficult to establish that several gaps were left and the stand was irregular. Strain 7 on the other hand required practically no supplying. The number of vegetative and fruiting branches was recorded for each plant but lack of time prevented any examination of the figures.

A variety test for yield was attempted, using seed from the 1924 progeny rows (five different strains selfed for two generations) using the soil fertility curve method (2), but owing partly to the very poor yield obtained and partly to the sudden and large variations in the fertility of the soil (values as low as thirteen and as high as forty-one being found), the results were not thought worth recording.

LITERATURE CITED.

1. Martin and Mason. This Bulletin, 1924.

2. Sarkar ... ... Agricultural Journal of India, Vol. XVIII.

Lint Index.—WEIGHT OF LINT (IN DECIGRAMS) OBTAINED FROM 100 SEEDS.

1925 Strain No.	Mean.	Probable error of Mean.	Standard Deviation.	Coefficient of Variability.	1924 Lint Index of Parent Plant.
1	41	± ·4	3·68	8·98	38
2	39·7	± ·31	3·16	7·96	40
3	49·4	± ·69	7·12	14·4	48
4	52·7	± ·62	6·26	11·9	56
5	49·7	± ·62	6·57	13·2	60
6	48·2	± ·53	5·25	10·9	55
7	47·3	± ·60	5·87	12·4	54
8	43·3	± ·57	6·00	13·8	48
9	37·2	± ·44	4·44	11·9	36
Values for the 1923 population	40·1	...	6·11	15·2	...

Lint per boll—(in decigrams).

1925 Strain No.	Mean.	Probable error of Mean.	Standard Deviation.	Coefficient of Variability.	1924 Lint per boll of Parent Plant.
1	12·2	± ·21	1·99	16·3	11·8
2	11·7	± ·17	1·73	14·8	12·1
3	13·1	± ·29	3·02	23·1	18·1
4	14·4	± ·22	2·18	15·2	17·1
5	15·1	± ·28	2·96	19·6	23·6
6	14·5	± ·3	3·03	20·9	23·1
7	14·9	± ·26	2·48	16·6	26·1
8	13·2	± ·26	2·76	20·9	19·8
9	10·7	± ·23	2·29	21·4	12·8
Values for the 1923 population	10·8	...	2·65	24·5	...

Lint length.—(MEAN MAXIMUM) IN MILLIMETRES.

Determined firstly for each plant on ten seeds taken at random. The means for strains (of fifty-one plants) are given below.

1925 Strain No.	Mean Max. Lint Length.	Probable error of Mean.	Standard Deviation.	Coefficient of Variability.	1924 Mean Max. Lint Length of Parent Plant.
1	34	± ·12	1·12	3·29	37
2	33·9	± ·10	1·04	3·07	36
3	34·5	± ·13	1·32	3·83	34
4	33·0	± ·15	1·5	4·55	32
5	33·16	± ·16	1·7	5·13	34
6	34·6	± ·11	1·13	3·27	35
7	34·4	± ·17	1·63	4·74	35
8	35·3	± ·12	1·25	3·55	39
9	33·8	± ·16	1·59	4·70	37
25·1	34·6	± ·17	1·69	4·88	36
25·2	34·6	± ·21	2·14	6·18	37
25·3	34·9	± ·18	1·87	5·36	36
25·4	34·8	± ·15	1·56	4·48	36
25·5	34·2	± ·15	1·57	4·59	36
Hartsville Values for the 1923 population	32·0	± ·17	1·79	5·59	...
	29·9	...	2·86	9·6	...

Strains 25·1 to 25·5 are from single field selections of 1924.

Seed Weight.—WEIGHT OF 100 SEEDS IN DECIGRAMS.

1925 Strain No.	Mean.	Probable error of Mean.	Standard Deviation.	Coefficient of Variability.	1924 Seed weight of Parent Plant.
1	88·9	·76	7·02	7·9	75
2	84	·62	6·27	7·47	74
3	100	·84	8·72	8·72	88
4	97·5	1·1	11·2	11·5	92
5	98·5	1·1	11·83	12·0	111
6	98·5	1·0	10·48	10·6	98
7	99·5	1·5	14·5	14·6	108
8	110·3	1·6	17·2	15·6	128
9	92·2	1·1	11·2	12·2	76
Values for the 1923 population	91·0	...	13·76	15·1	...

Ginning %.

1925 Strain No.	Mean.	Probable error of Mean.	Standard Deviation.	Coefficient of Variability.	1924 Ginning % of Parent Plant.
1	31·5	·22	2·03	6·45	34·4
2	32·1	·14	1·47	4·58	35·0
3	32·8	·17	1·72	5·25	35·0
4	35·1	·15	1·5	4·27	37·8
5	33·4	·14	1·45	4·34	35·2
6	32·8	·16	1·63	4·97	35·8
7	32·7	·20	1·99	6·08	33·6
8	28·3	·18	1·84	6·50	27·3
9	28·8	·17	1·69	5·86	31·9
25–1	29·3	·22	2·26	7·71	27·8
25–2	29·6	·20	2·08	7·03	28·5
25–3	28·9	·18	1·87	6·47	28·7
25–4	28·7	·18	1·92	6·69	30·6
25–5	27·9	·22	2·31	8·28	26·2
Values for the 1923 population	30·5	...	2·72	8·9	...

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Fertility Experiments.

Investigations have been continued on the same lines as in the past few years, and experiments have for the most part been concerned with questions of fertility. The final aim of these experiments is to discover a system of continuous cropping that would commend itself to native cultivators and replace to some extent the existing methods of shifting cultivation. Any discussion as to the merits of such a change from the point of view of rural sociology is outside the scope of this report, but an examination of the purely agricultural factors involved and a general statement as to recent progress may be useful, before dealing with each experiment individually.

In the Southern Provinces, west of the Niger River, mixed farming and the utilisation of farmyard manure is out of the question, owing to the prevalence of the tse-tse fly. Artificial fertilisers would be unlikely to find any favour with native cultivators on account of their cost. The problem therefore is reduced to that of utilising the resources of the soil to the best advantage by suitable rotations and intelligent cultivation, and of including in those rotations crops of an improving character, namely legumes. Our experiments have been designed, first to test the feasibility of maintaining a fair level of fertility by these methods, and secondly to discover ways of utilising leguminous crops to the best advantage in various rotations. The theoretical considerations which justify hope in the ultimate success of these experiments may be stated briefly as follows :—

1. The weathering of soils by physical conditions and living agencies is more rapid in the tropics than in temperate climates.

2. Leaching can be minimised by keeping the soil covered by some crop.

3. Leguminous crops appear to grow sufficiently luxuriously to provide all the nitrogen that is necessary.

With regard to the first problem, namely the feasibility of maintaining fertility by continuous cropping with frequent bean crops, it is as yet early to make deductions from our experiments. The four year main rotation has now been in existence for four years and the yields obtained last season were variable. The maize crop yielded slightly more than average, the yields of yams and of groundnuts were low, cotton yielded well, and the late maize yield was fair. The failure of the yam crop was probably due to causes other than fertility, for lack of labour in the early part of the year precluded frequent weeding and early sticking. Groundnuts suffered from an unfavourable season, and were probably adversely affected by too rich a soil. The late maize crop was badly laid by a severe tornado. The comparative failure of the crops mentioned was not confined to the "fertility" plots, but was general over the whole plantation. On the whole therefore the crops were fair; there is no reason to believe that the main rotation plots are going back in fertility. The value of green manuring is becoming increasingly evident on some fields, notably in the manurial, grass-fallowing, and green manuring experiments, and a review of the experiments now being conducted leads one to anticipate fairly conclusive results in a few years' time. The "Dhub grass" mentioned in the last report has made further headway on some plots. This grass has spread from the roads with which the plantation is intersected, which were planted with this pernicious weed over ten years ago. This condition would not be likely to come to pass on native farms if continuously cultivated in the bush.

With regard to the second problem, namely that of discovering ways of utilising bean crops to the best advantage, some experiments are already giving results, some have only just been laid down, and others are under contemplation. Among new experiments may be mentioned :—

1. The effect of digging beans in November while the crop is still green and the soil moist, as compared with leaving it to cover the land and mature during the dry season.

2. The comparative effect of moulding up the old ridges as compared with split ridging.

3. The effect of allowing the bean crop to rot after cutting as compared with digging it in green.

4. Bush fallowing for four years, as compared with perpetual cultivation, in stumped and unstumped land.

The possibility of breeding an edible bean suitable for export is receiving special attention. Many introduced varieties were tested this year, but they did not yield as well as the local bean "Popondo."

In undertaking a problem of this magnitude, it is evident that no point in the cultivation of each crop can be disregarded, however small, and that the provision of accurate information on all pertinent questions, however trivial, is essential. For this reason we have had to study such questions as spacing, size of ridges, and depth of planting, with rather more wealth of detail than might otherwise be necessary, and useful results of this nature have been obtained in the past season.

Cultivation.

The normal method of preparatory cultivation practised on the Plantation has hitherto consisted in putting the land into ridges $3\frac{1}{2}'$ apart, but it has now been decided to substitute larger ridges, viz, $6'$ apart. Many considerations are involved in this question and the economic considerations have not yet been fully investigated. The larger ridges have been adopted more for convenience than on the conviction that they are the best. At the same time recent experiments show that yams and maize yield better on a large ridge, and that cotton grows at least as well: groundnuts, which are not an important crop here, yield nearly as heavily as on small ridges.

General.

Now that the uniform method of "laying out" field trials (adopted in 1922) has been followed on Moor Plantation for four seasons, it can be confidently stated that the system is sound in practice. A knowledge of the fertility of the various plots on the farm is becoming increasingly useful for the estimation of the probable error and the extent to which the results are reliable. By establishing conclusive evidence with regard to each single factor problem, and piecing together these results, we are gradually acquiring a store of reliable data which would only be conjecture if obtained under less modern experimental methods.

In the following pages, the same order has been kept as in previous reports, and no attempt has been made to follow any order of importance.

Cotton Variety Tests.

Allen *Versus* Ishan and Meko.

	Yield of seed cotton lb. per acre.	Odds that difference is significant.
Block A6. (Table No. II.)		
Average yield 10 plots Allen cotton	286	
Average difference 5 plots Ishan cotton	+146±22	∝ : 1
Average difference 4 plots Meko „	+153±25	∝ : 1
Adio Plots. (Table No. III.)		
Average yield 9 plots Allen cotton	185	
Average difference 4 plots Ishan cotton	+199±15	∝ : 1
Average difference 4 plots Meko „	+229±15	∝ : 1
Block 5. (Table No. IV.)		
Average yield 20 plots Allen cotton	163	
Average difference 8 plots Ishan cotton	+160±11	∝ : 1
Average difference 9 plots Meko „	+146±10	∝ : 1
Block A5 through Yams. (Table No. V.)		
Average yield 22 plots Allen cotton	47	
Average difference 10 plots Ishan cotton	+ 61± 8	∝ : 1
Average difference 8 plots Meko „	+ 71± 8	∝ : 1
Oyo Plots. (Table No. VI.)		
Average yield 15 plots Allen cotton	118	
Average difference 5 plots Ishan cotton	+ 47±20	105 : 1
Average difference 5 plots Meko „	+ 68±20	3029 : 1

Percentage of Clean Cotton.

	Allen.	Ishan.	Meko.
Block A6	46%	60%	41%
Adio Plots	71%	93%	81%
Block B5	37%	49%	46%
Block A5	44%	63%	57%
Oyo Plots	61%	61%	45%

The various variety tests in which the two main native varieties, Ishan and Meko, have been tested against Allen cotton have in all cases given definite results in favour of native cotton this year. The native cotton was planted between July 1st and July 10th, and the Allen cotton between July 10th and July 15th. Many of the native farmers in the neighbourhood had not planted

their cotton by this date, and, as a period of drought followed, they were unable to plant till a fortnight later. It is believed that our farm yields were heavier than theirs for this reason. In all the experiments, each quarter acre plot of native cotton was grown between plots of Allen cotton so that the yields of the native cotton plots may have suffered unduly through stainer infestation. (Golding, p. 73, Fourth Bulletin.)

In Block A6 (*see* yields above) the cotton covered the land well in all the plots. Germination and cultivation was good and avoidable experimental error practically nil. Both the Ishan and Meko cotton yielded half as heavily again as the Allen cotton.

At the Adio plots, the cotton plants were sown on the tops of the ridges instead of on the sides as in Block A6, so that the Allen cotton was at a slight disadvantage in this respect, for Allen cotton plants are smaller and not so deep rooted. If this is taken into consideration the comparative and actual yields are very similar to those of A6. The Adio plots were contained in a block of five acres, which had been cut out of fairly thick high bush about four miles W.N.W. of Moor Plantation. There were many native farms growing cotton in the vicinity, but the block itself was screened by a belt of bush which had not been cleared.

Block B 5 was planted at the same spacing as the Adio plots, and the comparative yields were similar but not so heavy. Maize was interplanted with the cotton in September but completely failed. This block has a light dry soil and has been cropped since 1922 : the Northern half (plots 1–20) was badly overrun with dhub grass. The germination of the cotton this year was good, and the results are useful in comparing those of A6, and the Adio Plots.

Cotton was planted through yams in A5. Germination was bad and a resultant stand of only 1,300 plants per acre was obtained. The yield results from this block are therefore of little value, but even so they agree very well with the other experiments.

At Oyo the difference in yield between Allen cotton and the native varieties was not so great. The Allen cotton was planted at the same spacing as block B5 and the Adio plots, and owing to poor growth did not cover the land properly. The weather was unfavourable and the yield low.

These results can be summarised by saying that native cotton gave an increased yield compared with Allen cotton of at least 50%, and that Meko and Ishan yielded equally well. Ishan yielded a lint containing a higher percentage of clean cotton than either Allen or Meko cotton.

Native Cotton Spacing Test.

Distance of Planting (Table No. VII.)

	Yield of Seed Cotton, lb. per acre.	Odds that difference is significant.
Average yield 5 plots spaced at 2′	147	—
Average difference 2 plots spaced at 1′	+6 ± 10	3 : 1
Average difference 2 plots spaced at 3′	+8 ± 10	4 : 1

The cotton for this test was grown in single stands and single rows on 6′ ridges. The results show that reducing the distance between plants from 3′ to 1′ which is equivalent to an area per plant of from eighteen to six square feet, made practically no difference to the yield. This experiment demonstrates that native cotton is capable of producing its maximum yield within extremely wide limits of spacing and confirming that our practice of allowing twelve square feet per plant on normal land is sound. This adaptability of native cotton explains to some extent how the native cultivator is enabled to reap a fair crop from cotton planted about six at a stand and not thinned, on hills about four feet apart, and intersown with yams or early maize.

Native Cotton Spacing Test.

6′ *versus* 3½′ Ridges (Table No. VIII.)

	Yield of Seed Cotton, lb. per acre.	Odds that difference is significant.
Average yield 5 plots in 6′ ridges	156	
Average difference 4 plots in 3½′ ridges...	−7 ± 8	4 : 1

The spacing of this test was so arranged that the same number of plants grew on each plot. Two rows of cotton were planted on each side of the 6′ ridges, and one row along the top of each 3½′ ridge. The results show that there was very little difference between the yields obtained from 6′ ridges and from 3½′ ridges; the slight decrease recorded for the 3½′ ridges cannot be considered definite evidence as to their inferiority. At the same time, now that all the crops on the farm are normally grown on 6′ ridges instead of 3½′ ridges as before, this experiment indicates that this change in the ridging will not result in lower cotton yields on the farm, but rather the reverse.

Allen cotton following Mucuna and Groundnuts.

(Table No. IX.)

	Yield of Seed Cotton, lb. per acre.	Odds that difference is significant.
Average yield 10 plots following Mucuna	299	—
Average yield 8 plots following Groundnuts	− 142 ± 16	∝ : 1

Results obtained during the past two seasons indicate that groundnuts are of equal value with green manure as a preparation for cotton, when the cotton sowing is delayed until after the groundnut haulmes have been dug in. Early sowing of cotton however has been shown to be the best, and this season, cotton following mucuna was tested against cotton interplanted in groundnuts. Great difficulty was experienced in getting a good field of cotton, when it was interplanted between the groundnut rows which were only $3\frac{1}{2}'$ apart. Under these conditions, cotton following mucuna gave a much better yield.

Early Maize—Spacing Experiment.

Wide *versus* Narrow Ridges.

(Table No. X.)

	Yield of dry grain, lb. per acre.	Odds that difference is significant.
Average yield 10 plots, 3′ ridges	1,809	—
Average difference 9 plots, 6′ ridges	+ 139 ± 77	27 : 1

A single row of plants was planted on each 3′ ridge and two rows on each 6′ ridge, so there were the same number of plants on each plot. The 6′ ridge were wider and higher, and the soil to make them was moved through a greater average distance, but the cultivation was no deeper. The maize on the 6′ ridges looked healthier from the start and gave a distinctly better yield than the maize on the narrow ridges. In plots Nos. 14 to 19, some self-sown beans covered the maize in places before the latter was quite ripe; this smothering was greater in the plots with 6′ ridges. Omitting this portion of the field, the yield of the remaining plots (Nos. 1 to 13) was 1,836 + 258 ± 84 lb. per acre (odds 740 : 1), which is a conclusive result in favour of the wider ridges. Experiments in previous years have not

shown any great difference between ridges of from 3′ to 7′, but this is the first time that the test has been carried out with a large number of plots. These results may be summarised by saying that a decreased yield of 15% can reasonably be expected if 3′ ridges are used in place of 6′ ridges, but that climbing beans, either self-sown, or interplanted, are more liable to get out of control and to smother the maize.

Early Maize—Number of Plants at a Stand.

(Table No. XI.)

	Yield of dry grain, lb. per acre.	Odds that difference is significant.
Average yield 10 plots, 2 plants at a stand	2,172	—
Average difference 9 plots, 1 plant at a stand	— 145 ± 143	6 : 1

Self-sown beans were allowed to grow in the maize, and in parts of the field they climbed the stalks and almost covered the maize towards the end of the growing season. The plots planted one at a stand suffered the most in this respect. If the plots in which this occurred are omitted the difference due to planting one at a stand is only about one half of that shown above.

The stands were spaced at a distance of eighteen inches on both sides of 6′ ridges, and there were twice as many maize plants in the plots with two plants at a stand. The result shows that a slightly greater yield was obtained with two plants at a stand, but it does not prove that it is always best to grow maize plants in pairs. It is possible that a still greater yield would have been obtained with the maize planted at a closer distance with one plant at a stand. On the other hand, possibly two plants at a stand will always result in a greater return, as the failure of one plant when planted singly means the failure of the stand. This is a subject that will be investigated next year, when special attention will be paid to barren plants, and their influence on an experiment of this nature.

When the maize was nearly ripe, one or two tornadoes swept the field. The single plants, having thicker and stronger stalks than those in pairs, withstood these tornadoes much better, and they remained standing, while the plants in pairs were badly laid in places. Had so severe a tornado come earlier in the season, the yield of the latter might have been considerably reduced.

This test has shown therefore that, when an area of $4\frac{1}{2}$ square feet per stand is allowed on a field of average fertility here, the increased yield to be obtained by duplicating the number of plants and growing them in pairs instead of singly is very small, and stands of single plants are less likely to be laid by wind and rain.

Manurial Experiment. (Table No. XII.)

The results obtained from the Manurial experiment this year cannot be viewed with any confidence. The cropping was yams and maize in A3N. and yams and beans in A3S, but the germination and growth of the yams were extremely poor and variable, and the late maize was partly spoilt by a tornado. The late maize yields are given in table No. XII, and show slight increases in favour of the manured plots as usual.

Ten tons of Nigerian phosphatic rock have been sent to England to be ground to very fine powder, and part of this will be used on the appropriate plots next season.

Cover Crop experiment. (Table No. XIII.)

	Yield of maize in dry grain lb. per acre.	Odds that difference is significant.
Average yield 11 plots following Dolichos	546	—
Average difference 2 plots following Canavalia	− 10 ± 138	—
Average difference 2 plots following Mucuna	− 18 ± 138	—
Average difference 2 plots following Cowpeas	+ 31 ± 138	—
Average difference 1 plot following Dolichos dug in December 1st	+ 186 ± 195	5 : 1
Average difference 1 plot following weeds (not cultivated)	− 146 ± 195	3 : 1
Average difference 1 plot following weeds cultivated December 1st and Jan. 1st.	− 70 ± 195	2 : 1

The second season of this experiment has given similar comparative results to those obtained for the first. The yield of maize obtained, however, was considerably less, and the field is evidently losing fertility. This field has always been looked upon as a poor one, and it is possible that it was not originally at a sufficiently high level of fertility to derive much benefit from a bean crop of short duration. The beans have never grown very well there and have not formed a thick cover as on other fields of the farm.

The above yields show that there was little significant difference between the various treatments. The increase shown for the plot "Dolichos dug in December 1st" is unreliable evidence of the superiority of this treatment, for the cropping for the past three seasons has shown that a sudden increase in the fertility of the field occurs in the vicinity of this plot; but the importance of estimating the value of this treatment has been recognised and a special experiment with a large number of plots has been laid out for the purpose.

The best method for the management of leguminous cover crops here has not yet been determined. When interplanted with early sown crops the green crop can be dug in in November, with the result that the bare soil is exposed during the dry season, or the crop can be left to cover the land during the dry season, in which case it matures and dies down before it is dug under in March or April. An alternative method would be to plant very late, say in October, either as a sole crop or interplanted with late-sown crops, and so obtain a green cover throughout the dry season, suitable for digging in green in April or in June. In support of this contention it may be mentioned that some cover crops have managed to survive the dry season this year.

Groundnuts—Varieties.

(Table No. XIV).

	Yield of dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield 20 plots in Native Zaria ...	813	—
Average difference 6 plots in Mache Atsugune	− 87±75	7 : 1
Average difference 6 plots in Ilorin No. 2	−128±75	22 : 1
„ „ 6 „ Chinese ...	− 52±75	3 : 1

These results confirm those of the past two seasons and show that Native Zaria can be relied on to give the best return here. Germination was good, but weeds were troublesome during early growth. The low yield recorded is attributable to the unfavourable season.

Various varieties, both exotic and indigenous, have been tested since 1915, and there appears to be little to choose between them. Varieties newly imported from Northern Nigeria have invariably held their own (compare Zaria in 1915, Mache Atsugune in 1920, Kano in 1922, Native Zaria in 1923), and there is no reason to believe that any increase in yield has been obtained as the result of acclimatization. It has been decided therefore to discontinue these groundnut variety tests and to look elsewhere for a variety

or strain which is suited to conditions here. It is worthy of note that groundnuts are not grown as a field crop in the neighbourhood of Ibadan, presumably because it does not pay farmers to grow them. Our experiments have shown that the seasonal yield is extremely variable, that the cost of harvesting and difficulty of drying is considerable, and that the quality and condition of the nuts is sometimes poor.

These disadvantages are mainly due to the fact that the fruiting and harvesting occurs in the middle of the rainy season.

But our fertility experiments demonstrate more and more clearly each year that groundnuts should be regarded as an improving crop and not merely as of neutral value. In addition the yields of the past few years have shown that the more fertile plots, as shown by a high yield of maize in the next season, give poorer yields of groundnuts; observation on the field has confirmed that the better looking plots of groundnuts with the more luxuriant growth usually give inferior yields. We therefore consider that a continued study of the groundnut crop will eventually be repaid.

Groundnut—Time of Planting.

(Table No. XV).

	Yield of dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield 10 plots sown April 7th ...	549	—
„ difference 9 plots sown March 13th	+421±42	over 100,000 : 1

The germination of the March sown nuts was good, while that of the April sown seed was poor. The disparity in germination however was nothing like as great as the resultant difference in yield, and it can be confidently stated, as the result of two seasons' experiments, that early sowing is the best. There was no great difference between the plots as regards the incidence of "bunching."

Groundnuts—Size of Ridges Experiment.

(Table No. XVI).

	Yield of dry unshelled nuts lb. per acre.	Odds that difference is significant.
Average yield 10 plots, in ridges 3′ apart ...	574	—
„ difference 9 plots, in ridges 6′ apart	−65±47	11 : 1

Two rows of plants were sown on the 3′ ridges and four rows on the 6′ ridges. The germination was fair, but weeds were prolific, and weeding was not done frequently enough. The result is interesting, as observations of the plots during growth indicated that the yield of the 6′ ridges would be markedly lower. As can be seen however from the yields, there was very little difference between them.

Yams—Size of Ridges Experiments.

(Table No. XVII).

	Yield of tubers lb. per acre.	Odds that difference is significant.
Average yield 10 plots, in ridges 3′ 6″ apart	3,997	—
„ difference 4 plots, in ridges 5′ 3″ „	+1,135±396	530 : 1
„ „ 4 „ „ 7′ 0″ „	+2,007±396	over 100,000 : 1

The usefulness of this test was somewhat mitigated by the poor yields obtained. It is believed that this failure was almost entirely due to germination, insufficient weeding during the early stage of growth, and late sticking. The yams in the smaller ridges appeared to suffer most from the effects of delayed weedings. Under these conditions there was no doubt as to the superiority of the larger ridges. An examination of the figures for germination and for yield indicates that the increased yield in the plots in 5′ 3″ ridges was almost entirely due to the size of ridges, and that the increased yield of the plots in 7′ ridges over those in 5′ 3″ ridges was mainly due to better germination. It has recently been decided to adopt 6′ ridges instead of 3½′ ridges as the normal method of preparation on the Plantation, and this change will certainly benefit the crop.

Yams—Deep Planting *versus* Ordinary Planting.

(Table No. XVIII).

	Yield of tubers lb. per acre.	Odds that difference is significant.
Average yield 10 plots ordinary planting	5,498	—
„ difference 9 plots deep planting	−1,086±333	1,720 : 1

In this experiment, "ordinary planting" consisted in placing the set in a position about four inches from the top of the ridge and covering with loose soil. In the case of the deep planted plots, one

half of the ridge was first formed and the yams put in position and then the other half was made and the sets covered during the process. Any deductions that can be made from this experiment must be viewed with exceptional suspicion as the yield was extremely low.

But an examination of the number and size of yams obtained from the various plots shows that the decreased yield of the deep planted plants was almost entirely due to the comparatively smaller size of the fair-sized yams produced. The inference is therefore that deeper planting results in smaller yams, and that any greater protection that the sets enjoy by being planted deeply is more than offset by the smaller size of the yams obtained. This point is being tested more fully next season.

Yams—Deep Digging *versus* Ordinary Digging.

(Table No. XIX).

	Yield of tubers lb. per acre.	Germination
Average yield 10 plots ordinary digging ...	4,952	77%
,, difference 9 plots deep digging ...	-592 ± 382	66%

Experiments in previous years have shown that trenching gives bigger yields, but may not be a profitable operation. In this year's test, the additional treatment which the "deep dug" plots received consisted in digging the bottoms of the old furrows before the new ridges were made. By this method it was hoped to obtain the increased yield caused by trenching with a minimum increase in labour costs.

The reliability of the present experiment was affected by the variability of sets used for planting. The seed used for the "deep dug" plots was for the most part obtained from a different source than the rest, and not only gave a lower germination, but also resulted in inferior growth. If the figures are weighted to take into account the germination, then the "deep dug" plots show a slight increase in yield over the "ordinary" plots. The experiment is being repeated next year. Especial care is necessary in experiments with the yam crop. Seed should be of the same size, the same quality, the same type, and from the same source. Owing to the work and care entailed in the various field operations, it is often not possible or desirable to complete one particular operation

in all the plots in one day. Plots should however be planted, mulched, sticked, and weeded in sequence across the field, but in harvesting it is admissible to raise alternate plots as usual to guard against mixing the produce from plots, provided that the harvesting occupies a few days only.

Green Manuring Experiment.

(Table No. XX).

	Yields, maize in dry grain lb. per acre.	Odds that difference is significant.
Average yield 7 plots following Mucuna	1,054	—
Average difference 2 plots following Dolichos	— 23 ± 103	—
Average difference 2 plots following Canavalia	+ 26 ± 103	—
Average difference 2 plots following Cowpeas	— 126 ± 103	8 .. 1

The third year of this experiment has given interesting but not definite results. The late maize testing crop was very badly laid and broken by a tornado, and at one time it was thought that no result would be obtained at all. Despite this catastrophe, the maize gave a yield equal to that obtained in 1923, showing that the block has maintained and has most probably gained in fertility.

In 1925 Mucuna and Canavalia formed the best cover, dolichos did not smother weeds quite as well and cowpeas were comparatively poor. There was no significant difference between the yields of late maize following Mucuna, Canavalia, and Dolichos. With cowpeas, however, there was a definite decrease both in the yield and in the size of maize obtained. This experiment is being continued, and any differences between the manurial value of the various green manures should become more marked each season owing to the cumulative effect of the same treatment year after year. If, however, all the plots are gaining fertility, the law of diminishing returns will have to be taken into consideration, for as the yields increase, so will the difference in yields tend to decrease. This law will therefore operate in opposition to the cumulative effect, and allowance by calculation will have to be made.

Grass Fallowing Experiment.

Early Crop—Yams. (Table No. XXI).

	Yields of tubers lb. per acre.	Odds that difference is significant.
Average yield 10 plots cultivated continuously	3,529	—
Average difference 2 plots, two years' fallow, woody-weeds removed yearly	− 842 ± 638	—
Average difference 2 plots, three years' fallow, woody-weeds removed yearly	− 1,572 ± 638	—
Average difference 2 plots, three years' fallow, woody-weeds left ...	− 1,480 ± 638	—
Average difference 2 plots, three years' fallow, bush burnt yearly ...	− 1,224 ± 638	—
Average difference 8 plots, two or three years' fallow	− 1,277 ± 319	—

Late Crop—Maize. (Table No. XXII).

	Yields dry grain lb. per acre.	Odds that difference is significant.
Average yield 5 plots cultivated continuously	623	—
Average difference 1 plot, two years' fallow, woody-weeds removed yearly	− 94 ± 155	—
Average difference 1 plot, three years' fallow, woody-weeds removed yearly	− 10 ± 155	—
Average difference 1 plot, three years' fallow, woody-weeds left ...	+ 52 ± 155	—
Average difference 1 plot, three years' fallow, bush burnt yearly ...	+ 147 ± 155	—
Average difference 4 plots, two or three years' fallow	+ 24 ± 78	—

This experiment was started in 1922 and the cropping for 1922 and 1923 is given in a previous bulletin (page 77, Third Bulletin).

In 1924 the plots "cultivated continuously" grew two crops of beans, Mucuna in the early rains, and Dolichos in the late rains. The "fallow" plots remained in grass bush. In 1925, the germination of the yam crop was poor and growth was delayed by late weeding and sticking, so that the yield was low. Under these conditions, the yield of the "fallow" plots was markedly inferior to that of the cultivated plots, but owing to the small number of plots under each treatment, no significant difference between the various treatments of the "fallow" plots could be expected.

A late maize crop was grown on one half of the field, and in this case the "fallow" plots gave a yield nearly equal to that of the "cultivated" plots.

This test has been useful in that it justifies hope for the ultimate success of experiments designed to discover a satisfactory system of continuous cultivation.

Palm Wine. (Table No. XXIII).

The records from those trees tapped since 1917 are still being kept. Only five trees of the original ten trees are now bearing inflorescences for tapping, while one of these yielded only one male flower during the year. No fruit was born by any of the tapped trees during the year.

Kola. (Table No. XXIV).

The plot of Gbanja kola gave three times the yield of last year. The number of pods attacked by various insect larvæ was high and 64% of the nuts were damaged in this way.

Coffee. (Table No. XXV).

The Abeokuta coffee in A2 S.W., together with the Bengal and Liberian coffee yielded so badly during the year that the crop must be looked upon as a complete failure this season. Early in the year the trees in alternate rows in A2 S.W., were drastically pruned as they had become so high and slender as to make picking very difficult, but this pruning will not explain the meagreness of the crop from the rest of the plots.

Coconuts. (Table No. XXVI).

The ten acres of coconut palms planted in 1912 yielded a slightly bigger crop than in the previous year. Coconut palms although not really suited to the district, constitute a valuable crop the nuts being readily saleable locally at 1d. each. The percentage of bad nuts is still very high being 15% in the case of B1, and 32% in C1. The number of nuts yielded per mature tree was forty-one in B1 and seventeen in C1.

Distribution of Plants.

The following plants were distributed from the nursery during the year, 250 Coconut Palms, 870 Gbanja Kola plants, 915 fruit trees, 2,408 Ornamental plants, and 109 various economic plants.

Poultry.

During the year under review it was decided to discontinue the breeding of "Indian Game" and "Light Sussex" fowls at Moor Plantation and to keep only "Rhode Island Reds" as this breed thrives better than the others and is moreover very popular with the local inhabitants. It has been found possible to introduce new blood by bringing eggs from England and putting them under hens here but the percentage of hatchings is usually low in these imported eggs.

H. B. WATERS.

TABLE No. I.

Rainfall 1925.

Moor Plantation, Ibadan.

Month.	Rainfall in inches.	Average rainfall for a period of sixteen years from 1910 1925.
January	0·00	0·20
February	0·04	0·75
March	3·66	3·08
April	5·50	6·15
May	7·18	5·93
June	8·33	7·27
July	5·01	6·48
August	4·93	3·56
September	4·96	7·00
October	2·98	6·51
November	1·31	2·11
December	0·00	0·15
Total	43·90	49·19

TABLE No. II.

Cotton—Variety Test.

Allen *versus* Ishan and Meko.

Plot.	Variety.	Yield of seed cotton lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
Block A6S				Ishan	Meko
Plot 21	Meko ...		(620)		
22	Allen ...	288			
23	Ishan ...		588	+ 266	
24	Allen ...	356			
25	Meko ...		460		+ 136
26	Allen ...	292			
27	Ishan ...		420	+ 108	
28	Allen ...	332			
29	Meko ...		452		+ 140
30	Allen ...	292			
31	Ishan ...		364	+ 80	
32	Allen ...	276			
33	Meko ...		364		+ 124
34	Allen ...	204			
35	Ishan ...		376	+ 150	
36	Allen ...	248			
37	Meko ...		468		+ 212
38	Allen ...	264			
39	Ishan ...		412	+ 126	
40	Allen ...	308			
	Average ...	286		+ 146	+ 153

Each plot ¼ acre—Allen sown 14th July, 1925, Meko and Ishan sown 4th July, 1925—planted on both sides of 6′ ridges—6,160 Allen cotton plants per acre and 4,250 Meko and Ishan.

Root—mean—square—difference between neighbouring control plots 49 lb. per acre.

TABLE No. III.

Cotton Variety Test.

Allen *versus* Ishan and Meko.

Plot.	Variety.	Yield of seed cotton lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
				Ishan	Meko
Adio Plots					
Plot 1	Allen ...	(116)			
2	Ishan ...		(268)		
3	Allen ...	180			
4	Meko ...		432		+ 242
5	Allen ...	200			
6	Ishan ...		296	+ 102	
7	Allen ...	188			
8	Meko ...		380		+ 192
9	Allen ...	188			
10	Ishan ...		344	+ 144	
11	Allen ...	212			
12	Meko ...		456		+ 264
13	Allen ...	172			
14	Ishan ...		364	+ 208	
15	Allen ...	140			
16	Meko ...		384		+ 216
17	Allen ...	196			
18	Ishan ...		536	+ 342	
19	Allen ...	192			
20	Meko ...		(364)		
	Average ...	185		+ 199	+ 229

Each plot ¼ acre—Allen sown on 15th July, 1925, Meko and Ishan sown on the 7th and 10th July, 1925—planted on the tops of 6′ ridges—4,600 Allen cotton plants per acre and 3,070 Meko and Ishan.

Root--mean—square—difference between neighbouring control plots 29 lb. per acre.

TABLE No. IV.

Cotton Variety Test—Allen *versus* Ishan and Meko.

Plot.	Variety.	Yield of seed-cotton lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
				Ishan	Meko
B 5.					
Plot 1	Allen	196			
2	Meko ...		204		+ 30
3	Allen	152			
4	Ishan ...		240	+ 104	
5	Allen	120			
6	Meko ...		260		+ 150
7	Allen	100			
8	Ishan ...		444	+ 324	
9	Allen	140			
10	Meko ...		380		+ 262
11	Allen	96			
12	Ishan ...		300	+ 194	
13	Allen	116			
14	Meko ...		224		+ 116
15	Allen	100			
16	Ishan ...		356	+ 232	
17	Allen	148			
18	Meko ...		384		+ 240
19	Allen	140			
20	Allen	(100)			
21	Allen	184			
22	Ishan ...		212	+ 28	
23	Allen	184			
24	Meko ...		244		+ 60
25	Allen	184			
26	Ishan ...		260	+ 54	
27	Allen	228			
28	Meko ...		252		+ 28
29	Allen	220			
30	Allen	(188)			
31	Allen	192			
32	Meko ...		424		+ 250
33	Allen	156			
34	Ishan ...		400	+ 220	
35	Allen	204			
36	Meko ...		372		+ 174
37	Allen	192			
38	Ishan ...		328	+ 126	
39	Allen	212			
40	Allen	(216)			
	Average	163		+ 160	+ 146

Each plot ¼ acre—Allen sown 13th July, 1925, Meko and Ishan sown, 3rd July, 1925, planted on the tops of 6′ ridges—single Allen plants 1′ apart, Meko and Ishan 2′ apart.

Root—mean—square—difference between neighbouring control plots 31 lb. per acre

TABLE No. V.

Cotton Varieties through Yams—Allen *versus* Ishan and Meko.

Plot.	Variety.	Yield of seed-cotton lb. per acre.	Increase or decrease compared with mean of adjacent controls.	
			Ishan	Meko
A 5.				
Plot 1	Allen	20		
2	Ishan ...	84	+ 62	
3	Allen	24		
4	Meko ...	60		+ 26
5	Allen	44		
6	Ishan ...	80	+ 32	
7	Allen	52		
8	Meko ...	168		+ 118
9	Allen	48		
10	Ishan ...	120	+ 58	
11	Allen	76		
12	Allen	20		
13	Meko ...	116		+ 68
14	Allen	76		
15	Ishan ...	132	+ 62	
16	Allen	64		
17	Meko ...	144		+ 96
18	Allen	32		
19	Ishan ...	140	+ 104	
20	Allen	40		
21	Allen	32		
22	Ishan ...	60	+ 36	
23	Allen	16		
24	Meko ...	72		+ 44
25	Allen	40		
26	Ishan ...	116	+ 66	
27	Allen	60		
28	Meko ...	144		+ 92
29	Allen	44		
30	Ishan ...	120	+ 64	
31	Allen	68		
32	Allen	60		
33	Meko ...	128		+ 70
34	Allen	56		
35	Ishan ...	100	+ 48	
36	Allen	48		
37	Meko ...	108		+ 52
38	Allen	64		
39	Ishan ...	132	+ 74	
40	Allen	52		
	Average	47	+ 61	+ 71

Each plot ¼ acre—Allen sown 15th July, 1925, Meko and Ishan 6th July, 1925, germination and growth poor, and resultant stand extremely patchy, average number of plants per acre was 1,300 for all varieties.

Root—mean—square—difference between neighbouring control plots 24 lb. per acre.

TABLE No. VI.

Cotton Variety Test—Allen *versus* Ishan and Meko.

Plot.	Variety.	Yield of seed-cotton lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.	
				Ishan.	Meko.
Oyo Block 1.					
Plot 1	Allen ...	212			
2	Ishan ...		214	+ 29	
3	Allen ...	158			
4	Meko ...		218		+ 45
5	Allen ...	188			
Oyo Block 3.					
Plot 6	Allen ...	128			
7	Ishan ...		230	+ 63	
8	Allen ...	206			
9	Meko ...		280		+ 113
10	Allen ...	128			
Oyo Block 5.					
Plot 11	Allen ...	120			
12	Ishan ...		170	+ 46	
13	Allen ...	128			
14	Meko ...		188		+ 83
15	Allen ...	82			
Oyo Block 7.					
Plot 16	Allen ...	82			
17	Ishan ...		114	+ 41	
18	Allen ...	64			
19	Meko ...		78		+ 19
20	Allen ...	54			
Oyo Block 9.					
Plot 21	Allen ...	92			
22	Ishan . .		160	+ 56	
23	Allen ...	106			
24	Meko ...		176		+ 81
25	Allen ...	84			
Average		118		+ 47	+ 68

Each plot $\frac{1}{5}$ acre, each block 1 acre. Allen sown 16th July, 1925. Meko and Ishan 7th July, 1925. Harvested 1st—3rd February, 1926 and 14th April, 1926.

Root—mean—square—difference between neighbouring control plots 41 lb. per acre.

TABLE No. VII.

Native Cotton Spacing Test.

Distance of Planting.

Plot.	Distance between plants in each row	Yield of seed-cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B4W			
Plot 3	2′	120	
4	1′	116	− 17
5	2′	146	
6	3′	156	+ 9
7	2′	148	
8	1′	180	+ 26
9	2′	160	
10	3′	168	+ 7
11	2′	162	
	Average ...	147	

Each plot $\frac{1}{4}$ acre—sown 6th July, 1925. Harvested 17th December, 1925—23rd February, 1926.

Root—mean—square—difference between neighbouring control plots 14 lb. per acre.

Average yield 5 plots spaced at 2′ = 147 ... lb. per acre.
„ difference 2 „ „ „ 1′ + 6 ± 10 „ „ „
„ „ 2 „ „ „ 3′ + 8 ± 10 „ „ „

TABLE No. VIII.

Native Cotton Spacing Test.

6′ *Versus* $3\frac{1}{2}$′ Ridges.

Plot.	Distance between ridges.	Yield of seed-cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B4W			
Plot 11	6′	162	
12	$3\frac{1}{2}$′	166	− 1
13	6′	172	
14	$3\frac{1}{2}$′	156	− 15
15	6′	170	
16	$3\frac{1}{2}$′	152	− 4
17	6′	142	
18	$3\frac{1}{2}$′	132	− 7
19	6′	136	
	Average ...	156	− 7 ± 8

Each plot $\frac{1}{4}$ acre—sown 6th July, 1925—harvested 17th December, 1925—23rd February, 1926.

Root—mean—square—difference between neighbouring control plots 15 lb. per acre.

TABLE No. IX.

Cotton after Mucuna and Groundnuts.

Plot.		Previous Crops.	Yield of seed cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
B6NW				
Plot	1	Mucuna	268	
	2	Groundnuts	172	− 140
	3	Mucuna	356	
	4	Groundnuts	152	− 212
	5	Mucuna	372	
	6	Groundnuts	196	− 188
	7	Mucuna	396	
	8	Groundnuts	268	− 128
	9	Mucuna	396	
	10	Groundnuts	(144)	
B7SW				
	1	Mucuna	160	
	2	Groundnuts	84	− 96
	3	Mucuna	200	
	4	Groundnuts	88	− 150
	5	Mucuna	276	
	6	Groundnuts	160	− 120
	7	Mucuna	284	
	8	Groundnuts	184	− 100
	9	Mucuna	284	
		Average ...	299	− 142 ± 16

Groundnuts planted 11th April, 1925
Mucuna „ 13th „ 1925
Cotton „ 15th July, 1925

Cotton harvested 24th November, 1925—1st March, 1926.

Each plot $\frac{1}{4}$ acre.

Root—mean—square—difference between neighbouring control plots 45 lb. per acre.

TABLE No. X.

Early Maize—Size of Ridges Experiment—1925.

Plot	Distance between ridges.	Yield of dry grain lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Z7N			
Plot 1	3′	1,772	
2	6′	1,856	+ 234
3	3′	1,472	
4	6′	2,080	+ 470
5	3′	1,748	
6	6′	1,952	+ 184
7	3′	1,788	
8	6′	2,160	+ 328
9	3′	1,876	
10	6′	2,156	+ 234
11	3′	1,968	
12	6′	2,196	+ 98
13	3′	2,228	
14	6′	2,008	− 94
15	3′	1,976	
16	6′	1,592	− 186
17	3′	1,580	
18	6′	1,616	− 14
19	3′	1,680	
20	3′	(1,968)	Non-experimental.
	Average ...	1,809	+ 139 ± 77

Each plot $\frac{1}{4}$ acre—variety, "Lagos White"—stands 1′6″ apart on the tops of 3′ ridges and both sides of 6′ ridges—one plant at each stand—sown 11th April, 1925, harvested 13th August, 1925.

Average No. of dry husked cobs in 100 lb. = 474 for 3′ ridges.

= 468 for 6′ ridges.

Average percentage weight dry grain to dry husked cobs = 82·3% for 3′ ridges.

= 81·2% for 6′ ridges.

Root--mean—square—difference between neighbouring control plots 231 lb. per acre.

Note:—Self sown beans almost covered the maize plants in places, especially in plots 14 to 19, where there are two large hollows. The plots in 6′ ridges suffered the most in this respect.

TABLE No. XI.

Early Maize—Number of Plants at A Stand Experiment—1925.

Plot.	No. of plants at stand.	Yield of dry grain lb. per acre.	Increase (+) or decrease (—) compared with mean of adjacent controls.
Block Z7S.			
Plot 21	2	2,088	
22	1	1,916	— 216
23	2	2,176	
24	1	2,288	+ 54
25	2	2,292	
26	1	2,336	— 110
27	2	2,600	
28	1	2,316	— 116
29	2	2,264	
30	1	2,204	+ 98
31	2	1,948	
32	1	1,972	— 114
33	2	2,224	
34	1	1,924	— 40
35	2	1,704	
36	1	1,640	— 466
37	2	2,508	
38	1	1,820	— 394
39	2	1,920	
40	2	(2,524)	Non-experimental.
	Average ...	2,172	— 145 ± 143

Each Plot $\frac{1}{4}$ acre—variety "Lagos White"—Stands 1′ 6″ apart both sides of 6′ ridges—sown 7th April, 1925—harvested 17th August, 1925.

Average No. of dry husked cobs in 100 lb.=453 for 2 at a stand.
=426 for 1 at a stand.

Average percentage weight dry grain to dry husked cobs=87·7% for 2 at a stand.
=88·0% for 1 at a stand.

Root—mean—square—difference between neighbouring control plots 430 lb. per acre.

Note:—Self sown beans almost covered the maize plants in places, especially in plots 31–40. The plots planted at one in a stand suffered the most in this respect.

TABLE No. XII.

Manurial Experiment. (Late Crop).

No. of plot.	Treatment. Manure applied per acre yearly.	Crop.	Yield in dry grain lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A3N.					
Plot 1	No manure	Maize	296		
2	13 cwt. cotton seed	„		496	+ 170
3	No manure	„	356		
4	10 cwt. rock phosphate	„		292	− 8
5	No manure	„	244		
6	13 cwt. cotton seed and 10 cwt. rock phosphate ...	„		336	+ 12
7	No manure	„	404		
8	13 cwt. cotton seed	„		392	+ 22
9	No manure	„	336		
10	10 cwt. rock phosphate	„		396	+ 14
11	No manure	„	428		
12	13 cwt. cotton seed and 10 cwt. rock phosphate ...	„		528	+ 52
13	No manure	„	524		
	Average		370		

Each plot $\frac{1}{4}$ acre—maize sown 22nd September, 1925, harvested 8th February, 1926.

Average yield 7 plots unmanured ... ... 370 lb. per acre.

Average difference 2 plots manured with cotton seed + 96 ± 73 lb. per acre.

Average difference 2 plots manured with phosphate + 3 ± 73 „ „ „

Average difference 2 plots manured with both cotton seed and phosphate ... ... + 32 ± 73 „ „ „

Root—mean—square—difference between neighbouring control plots 103 lb. per acre.

TABLE No. XIII.

Cover Crop Experiment—1925.

Plot.	Late season treatment.	Crop.	Yield of dry grain lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y1.					
Plot 1	Dolichos	Maize	360		
2	Canavalia	„		424	− 56
3	Dolichos	„	600		
4	Mucuna	„		440	− 100
5	Dolichos	„	480		
6	Cowpeas	„		504	+ 44
7	Dolichos	„	440		
8	Canavalia	„		436	+ 36
9	Dolichos	„	360		
10	Mucuna	„		492	+ 64
11	Dolichos	„	496		
12	Cowpeas	„		524	+ 18
13	Dolichos	„	516		
14	Dolichos dug in December 1st	„		900	+ 186
15	Dolichos	„	912		
16	Weeds	„		620	− 146
17	Dolichos	„	620		
18	Weeds cultivated December 1st and January 1st	„		576	− 70
19	Dolichos	„	672		
20	Dolichos	„	1,056		Non-experimental.
	Average		546		

Variety Lagos White—sown 28th April, 1925—harvested 16th/17th September, 1925. Each plot 0·2 acre.

Average increase 2 plots following Canavalia as compared with Dolichos ... ... − 10±138

Average increase 2 plots following Mucuna as compared with Dolichos ... ... − 18±138

Average increase 2 plots following Cowpeas as compared with Dolichos ... ... + 31±138

Increase 1 plot following Dolichos dug in December 1st, as compared with Dolichos ... ... +186±195

Decrease 1 plot following Weeds as compared with Dolichos ... −146±195

Decrease 1 plot following Weeds cultivated as compared with Dolichos ... ... − 70±195

Root—mean—square—difference between neighbouring control plots 195 lb. per acre.

TABLE No. XIV.

GROUNDNUTS—VARIETY TEST—1925.

No. of Plot.	Variety.	Yield of dry unshelled nuts lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block D6 S.			
21	Native Zaria	748	
22	Mache Atsugune	604	− 192
23	Native Zaria	844	
24	Ilorin No. 2	624	− 40
25	Native Zaria	484	
26	Chinese	580	− 16
27	Native Zaria	708	
28	Mache Atsugune	932	+ 124
29	Native Zaria	908	
30	Ilorin No. 2	532	− 284
31	Native Zaria	724	
32	Chinese	864	+ 80
33	Native Zaria	844	
34	Mache Atsugune	800	− 120
35	Native Zaria	996	
36	Ilorin No. 2	708	− 282
37	Native Zaria	984	
38	Chinese	876	− 68
39	Native Zaria	904	
40	Native Zaria	(724)	Non-experimental.
Block D5 N.			
1	Native Zaria	1068	
2	Ilorin No. 2	868	− 108
3	Native Zaria	884	
4	Chinese	732	− 122
5	Native Zaria	824	
6	Mache Atsugune	692	− 180
7	Native Zaria	920	
8	Ilorin No. 2	780	− 10
9	Native Zaria	660	
10	Chinese	640	− 90
11	Native Zaria	800	
12	Mache Atsugune	664	− 60
13	Native Zaria	648	
14	Ilorin No. 2	740	− 42
15	Native Zaria	916	
16	Chinese	696	− 94
17	Native Zaria	664	
18	Mache Atsugune	604	− 96
19	Native Zaria	736	
20	Native Zaria	(656)	Non-experimental.

Each plot ¼ acre—sown 25th March—harvested 27th August to 9th September. 3½′ ridges.

Increase (+) or decrease (−) of plots in Mache Atsugune as compared with Native Zaria.	Increase (+) or decrease (−) of plots in Ilorin No. 2 as compared with Native Zaria.	Increase (+) or decrease (−) of plots in Chinese as compared with Native Zaria.
− 192 lb. per acre.	− 40 lb. per acre.	− 16 lb. per acre.
+ 124 " " "	− 284 " " "	+ 80 " " "
− 120 " " "	− 282 " " "	− 68 " " "
− 180 " " "	− 108 " " "	− 122 " " "
− 60 " " "	− 10 " " "	− 90 " " "
− 96 " " "	− 42 " " "	− 94 " " "
Average − 87 ± 75 lb. per acre.	Average − 128 ± 75 lb. per acre.	Average − 52 ± 75 lb. per acre.

Root-mean-square-difference between neighbouring pairs of control plots 183 lb. per acre.

TABLE No. XV.

GROUNDNUTS—TIME OF PLANTING TEST—1925.

No. of plot.	Time of planting.	Yield of dry unshelled nuts lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C3 W.			
Plot 1	April 7th	304	Non-experimental.
2	March 13th ...	1,024	Non-experimental.
3	April 7th	716	
4	March 13th ...	832	+ 199
5	April 7th	550	
6	March 13th ...	1,096	+ 601
7	April 7th	440	
8	March 13th ...	910	+ 532
9	April 7th	316	
10	March 13th ...	776	+ 426
11	April 7th	384	
12	March 13th ...	768	+ 354
13	April 7th	444	
14	March 13th ...	910	+ 413
15	April 7th	550	
16	March 13th ...	984	+ 349
17	April 7th	720	
18	March 13th ...	1,264	+ 494
19	April 7th	820	
20	April 7th	740	Non-experimental.
	Average ...	549	+ 421 ± 42

Each plot $\frac{1}{4}$ acre—variety Native Zaria.

Early sown planted in the shell, late sown planted decorticated. Harvested 27th August, 1925 to 2nd September, 1925.

Root- mean—square—difference between neighbouring control plots, 119 lb. per acre.

TABLE No. XVI.

GROUNDNUTS—SIZE OF RIDGES EXPERIMENT—1925.

No. of Plot.	Size of Ridges.	Yield of dry unshelled nuts per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C3 E.			
Plot 21	3′	640	
22	6′	652	+ 92
23	3′	480	
24	6′	560	+ 42
25	3′	556	
26	6′	388	− 132
27	3′	484	
28	6′	508	− 130
29	3′	792	
30	6′	524	− 216
31	3′	688	
32	6′	464	− 154
33	3′	548	
34	6′	564	+ 28
35	3′	524	
36	6′	476	− 18
37	3′	464	
38	6′	420	− 96
39	3′	568	
40	3′	308	Non-experimental.
	Average ...	574	− 65 ± 47

Each plot ¼ acre—variety Native Zaria.

Sown 24th March, 1925—harvested 3rd September, 1925.

Root—mean—square—difference between neighbouring control plots 140 lb. per acre.

TABLE No. XVII.

YAMS—SIZE OF RIDGES EXPERIMENT—1925.

No. of Plot.	Size of Ridges.	Yield of Yams as harvested.	Increase (+) or decrease (−) compared with mean of adjacent controls.	Percentage Germination.
Block Z5.				
Plot 1	3′ 6″	3,880		81%
2	5′ 3″	5,634	+1,837	69%
3	3′ 6″	3,714		65%
4	7′ 0″	7,912	+3,612	78%
5	3′ 6″	4,886		69%
6	5′ 3″	4,686	+ 263	68%
7	3′ 6″	3,960		71%
8	7′ 0″	4,458	+ 625	65%
9	3′ 6″	3,706		74%
10	3′ 6″	3,870	Non-experimental	74%
11	3′ 6″	3,424	Non-experimental	77%
12	3′ 6″	3,316		75%
13	5′ 3″	4,168	+ 207	57%
14	3′ 6″	4,606		69%
15	7′ 0″	6,728	+2,216	82%
16	3′ 6″	4,418		69%
17	5′ 3″	6,556	+2,232	78%
18	3′ 6″	4,230		68%
19	7′ 0″	5,318	+1,576	80%
20	3′ 6″	3,254		58%
	Average	3,997		

Each plot ½ acre—planted 6th February, 1925—harvested 3rd to 29th December, 1925. Early weedings were infrequent through lack of labour.

Increase (+) or decrease (−) of plots with 5′ 3″ ridges compared with 3′ 6″.	Increase (+) or decrease (−) of plot with 7′ ridges compared with 3′ 6″.
+ 1,837 lb. per acre	+ 3,612 lb. per acre
+ 263 „ „ „	+ 625 „ „ „
+ 207 „ „ „	+ 2,216 „ „ „
+ 2,232 „ „ „	+ 1,576 „ „ „
+ 1,135 ± 396 lb. per acre.	+ 2,007 ± 396 lb. per acre.

Root—mean—square—difference between neighbouring pairs of control plots 791 lb. per acre.

TABLE No. XVIII.

YAMS—DEEP PLANTING *versus* ORDINARY PLANTING—1925.

No. of Plot.	Treatment.	Yield of tubers lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A5N.			
Plot 1	Ordinary planting	4,568	
2	Deep planting	3,592	− 1,230
3	Ordinary planting	5,076	
4	Deep planting	3,408	− 1,982
5	Ordinary planting	5,704	
6	Deep planting	4,652	− 506
7	Ordinary planting	4,612	
8	Deep planting	4,144	− 1,474
9	Ordinary planttng	6,624	
10	Deep planting	4,416	− 1,810
11	Ordinary planting	5,828	
12	Deep planting	4,732	− 1,466
13	Ordinary planting	6,568	
14	Deep planting	6,188	− 242
15	Ordinary planting	6,292	
16	Deep planting	5,568	− 62
17	Ordinary planting	4,968	
18	Deep planting	3,848	− 1,004
19	Ordinary planting	4,736	
20	Ordinary planting	3,964	Non-experimental.
	Average	5,498	− 1,086 ± 333

Each plot $\frac{1}{4}$ acre—stands 2′ apart on 7′ ridges—sown with mixed sets on 11th to 13th November, 1924—harvested 15th to 20th January, 1926.

Root—mean—square—difference between neighbouring control plots 998 lb. per acre.

TABLE No. XIX.

YAMS—DEEP DIGGING *versus* ORDINARY DIGGING—1925.

No. of Plot.	Treatment.	Yield of tubers lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A58.			
Plot 21	Ordinary digging	3,872	
22	Deep digging	4,260	+ 534
23	Ordinary digging	3,580	
24	Deep digging	4,300	+ 524
25	Ordinary digging	3,972	
26	Deep digging	4,444	+ 348
27	Ordinary digging	4,220	
28	Deep digging	3,928	− 388
29	Ordinary digging	4,412	
30	Deep digging	3,952	− 1,270
31	Ordinary digging	6,032	
32	Deep digging	4,852	− 672
33	Ordinary digging	5,016	
34	Deep digging	4,876	− 682
35	Ordinary digging	6,100	
36	Deep digging	4,496	− 2,202
37	Ordinary digging	7,296	
38	Deep digging	4,636	− 1,520
39	Ordinary digging	5,016	
40	Ordinary digging	2,372	Non-experimental
	Average	4,952	− 592±382

Each plot $\frac{1}{4}$ acre—stands 2′ apart on 7′ ridges—sown with seed yams and "tops" on 19th November and 9th December, 1925—harvested on 22nd January, 1926.

Root—mean—square—difference between neighbouring control plots 1,145 lb. per acre.

TABLE No. XX.

Green Manuring Experiment—1925.

Plot.	Early crop.	Late crop.	Yield of dry grain lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block B 3E				
Plot 1	Mucuna ...	Maize	800	
2	Dolichos ...		892	+ 40
3	Mucuna ...	„	904	
4	Canavalia		976	− 4
5	Mucuna ...	„	1,056	
6	Cowpeas ...		824	− 296
7	Mucuna ...	„	1,184	
8	Dolichos ...		1,164	− 86
9	Mucuna ...	„	1,316	
10	Canavalia		1,252	+ 56
11	Mucuna ...	„	1,076	
12	Cowpeas ...		1,104	+ 44
13	Mucuna ...	„	1,044	
	Average		1,054	

Each plot $\frac{1}{4}$ acre—Green manure sown 31st March—dug in 24th August—late maize sown 4th September, 1925, harvested 11th February, 1926.

6′ between ridges—stands of single plants 1′ 6″ apart on both sides.

Increase (+) or decrease (−) of plots following Dolichos as compared with those following Mucuna.

+ 40 lb. per acre.
− 86 „ „

Average − 23 ± 103 lb. per acre.

Increase (+) or decrease (−) of plots following Canavalia as compared with those following Mucuna.

− 4 lb. per acre.
+ 56 „ „

Average + 26 ± 103 lb. per acre.

Increase (+) or decrease (−) of plots following Cowpeas as compared with those following Mucuna.

− 296 lb. per acre.
+ 44 „ „

Average − 126 ± 103 lb. per acre.

Root-mean-square-difference—between neighbouring control plots 145 lb. per acre.

Note:—The late maize was badly laid by tornadoes in November.

TABLE No. XXI.

Grass Fallowing Experiment (Early Crop, 1925).

Plot.	Previous Treatment.	Yield of Yams in tubers lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.	Percentage germination.
Z2.				
Plot 2	Cultivated continuously ...	2,818		64%
3	Two years' fallow—woody weeds removed yearly ...	2,372	− 1,108	65%
4	Cultivated continuously ...	4,142		65%
5	Three years' fallow—woody weeds removed yearly ...	2,378	− 1,718	70%
6	Cultivated continuously ...	4,050		70%
7	Three years' fallow—woody weeds left	2,730	− 1,730	66%
8	Cultivated continuously ...	4,870		66%
9	Three years' fallow—bush burnt yearly	3,790	− 717	70%
10	Cultivated continuously ...	4,144		70%
20	Cultivated continuously ...	2,796		58%
19	Two years' fallow—woody weeds removed yearly ...	2,452	− 555	56%
18	Cultivated continuously ...	3,218		55%
17	Three years' fallow—woody weeds removed yearly ...	2,054	− 1,426	46%
16	Cultivated continuously ...	3,742		55%
15	Three years' fallow—woody weeds left	1,778	− 1,229	49%
14	Cultivated continuously ...	2,272		48%
13	Three years' fallow—bush burnt yearly	1,026	− 1,731	52%
12	Cultivated continuously ...	3,242		59%
	Average	3,529		

	Yields of yams in tubers lb. per acre.
Average yield 10 plots cultivated continuously	3,529
Average difference 2 plots two years' fallow—woody weeds removed yearly	− 842 ± 638
Average difference 2 plots three years' fallow—woody weeds removed yearly	− 1,572 ± 638
Average difference 2 plots three years' fallow—woody weeds left	− 1,480 ± 638
Average difference 2 plots three years' fallow—bush burnt yearly	− 1,224 ± 638
Average difference 8 plots two or three years' fallow	− 1,277 ± 319

Note :—The cropping of the plots "cultivated continuously" was :—1922, Maize and late maize 1923, Groundnuts and cotton ; 1924, Mucuna and Dolichos beans ; 1925, yams.

TABLE No. XXII.

Grass Fallowing Experiment (Late Crop, 1925).

Plot.	Previous Treatment.	Yield of dry maize grain lb. per acre.		Increase (+) or decrease (−) compared with mean of adjacent control.
Z2N.				
2	Cultivated continuously	534		
3	Two years' fallow—woody weeds removed		560	− 94
4	Cultivated continuously	774		
5	Three years' fallow—woody weeds removed		690	− 10
6	Cultivated continuously	626		
7	Three years' fallow—woody weeds left		692	+ 52
8	Cultivated continuously	654		
9	Three years' fallow—bush burnt ...		738	+ 147
10	Cultivated continuously	528		
	Average	623		

Average yield of 5 plots cultivated continuously... ... ... 623 lb. of dry grain per acre.

Average difference of 1 plot, two years' fallow—woody weeds removed yearly − 94 ± 155

Average difference of 1 plot, three years' fallow—woody weeds removed yearly − 10 ± 155

Average difference of 1 plot, three years' fallow—woody weeds left ... ... + 52 ± 155

Average difference of 1 plot, three years' fallow—bush burnt yearly ... ... + 147 ± 155

Average difference of 4 plots, two or three years' fallow .. .. + 24 ± 78

Root- mean —square—difference between neighbouring control plots 155 lb. per acre.

TABLE No. XXIII.

Palm Tapping—1925.

No. of tree.	No. of periods.	Total No. of days in the periods.	Yield of wine in galls.	Yield of wine, 1917–1925 in galls.	Remarks.
1	...	...	...	72·94	Felled 1922.
2	7	128	1·50	108·55	
3	...	...	...	28·65	Only yielded for two years.
4	...	...	...	29·60	do.
5	1	11	0·025	19·52	Only yielded once in 1925.
6	...	...	...	27·34	
7	10	133	0·64	107·99	
8	...	...	...	41·09	Only yielded for four years.
9	5	46	0·26	28·72	
10	6	146	1·50	55·28	

TABLE No. XXIV.

Kola, 1925.

2·5 acres Gbanja Kola—planted 15′ × 15′ in 1913.

No. of Plot.	No. of collections.	No. of pods.	Weight of pods. in lb.	No. of Nuts.	Yield of nuts per acre in lb.
Y5	25	3,986	1,817	16,168	349

TABLE No. XXV.

Coffee. Planted 12′ × 12′ in 1915.

Plot.	Variety.	Area.	Yield of fresh berries per plot in lb.	Yield of parchment coffee per plot in lb.	Yield of parchment coffee per acre lb.	Remarks.
A2.	Abeokuta	1 ac.	63	28	28	Trees in alternate rows in A2 S pruned in 1925.
Y2SE.	Liberian	0·88 „	...	10·25	11·6	
Y2SW.	Bengal	0·88 „	22	10·5	11·9	

TABLE No. XXVI.

Coconuts, 1925.

No. of Plot.	Area.	Planting Distance.	No. of trees at end of year.			Vacancies.	No. of collection.	Yield.			
			Bearing.	Non bearing	Young Trees.			Good.	Bad.	Total.	% Bad.
B1	5	30′ × 30′	151	39	14	40	6	6,609	1,205	7,814	15·4%
C1	5	25′ × 25′	169	109	17	43	6	3,250	1,534	4,784	32·1%

TABLE No. XXVII.

Cost of Cultivation of main Annual Crops—1925.

Figures in man-days per acre obtained from plots of the Main Rotation.

Crop.	Preparation.	Establishing.	After cultivation.	Harvesting.	Store work.	Miscellaneous.	Total.	
Yams and	30	28	88	27	3	..	176	189
Cover Crop	...	3	...	10	...	...	13	
Green Manure and ...	11	1	11	...	...	...	23	107
Cotton	22	10	15	33	4	...	84	
Groundnuts and ...	24	10	23	86	25	...	168	178
Cover Crop	...	3	4	3	...	...	10	
Maize and	31	7	9	19	7	4	77	79
Cover Crop	...	2	...	...	...	...	2	

TABLE No. XXVIII.

Comparison of Costs of Production and Revenue for Main Rotation Crops, 1925–26 Season, Moor Plantation.

Cost of labour 11d. per man-day.

Crops.	Cost of crop in man-days per acre.	Average yield per acre lb.	Cost of production of crop in man-day per lb.	Market value per lb.	Calculated return per acre.	Monetary return per man-day.	Kind of crop.
Yams	176·5	4,697	·0375	At store ·482d.	2,264d.	12·84d.	
Cotton	84	1st grade 114		$2\frac{1}{8}$d.	242	6·643d.	Seed Cotton.
		2nd „ 144		$1\frac{7}{8}$d.	270		
		3rd „ 28		$1\frac{5}{8}$d.	46		
		Allen 286	·294		558d.		
		1st grade 150		$1\frac{3}{8}$d.	206	6·131d.	do.
		2nd „ 261		$1\frac{1}{8}$d.	$293\frac{1}{2}$		
		3rd „ 21		$\frac{3}{4}$d.	$15\frac{1}{2}$		
		Ishan 432	·194		515d.		
		1st grade 69		$1\frac{3}{8}$d.	95	3·0d.	do.
		2nd „ 128		$1\frac{1}{8}$d.	144		
		3rd „ 17		$\frac{3}{4}$d.	13		
		Meko 214	·39		252d.		
Ground-nuts	168	1,349	·125	At store 1·07d.	1,445d.	8·6d.	Undecorticated.
Early Maize	77	2,443	·032	At store ·321d.	784d.	10·18d.	Husked cobs.

ANNUAL REPORT, 1925, ON SAMARU AGRICULTURAL STATION, ZARIA, NORTHERN PROVINCES.

GENERAL :—

Total area of Station	...	...	707 acres.
„ „ under cultivation		...	120 „
Latitude	...	...	11° 12′ N.
Longitude	...	...	7° 37′ E.
Altitude...	...	...	2,200 feet (approximate).

Mean (Zaria) rainfall 1904–1925. 44·61 inches.
Distance from nearest point on coast. 400 miles (approximate).

The rainfall during the year under review was abnormal in many respects This was most particularly the case in March when 2·39 inches fell in one day.

As a result of this beans for early green manuring were planted but unfortunately April rains were much below average, causing the beans to die off and necessitating almost complete replanting.

In September, which has had, over a period of twenty years, an average rainfall of 9·59 ins. only 4·7 ins. fell, while 3·92 ins. fell in October and ·4 ins. in November, both of which are above the average.

Several of the showers in October, which totalled nine, fell towards the end of the month, and the November rain all fell on the 5th of the month : it is possibly not too much to say that this spreading out of the later rains, compared with their usual abrupt termination in mid-October, has had, judging by results, an appreciably advantageous effect on the cotton crop.

The direction of the ridging on practically the whole of the Samaru Farm was altered at the beginning of the season ; this operation has upset the farm costings to a considerable extent, as a good deal of additional labour was required to turn the new ridges.

Blocks A.Y. and Z. were unaffected by this, as were both Blocks at Bomo.

GENERAL CROP NOTES.

Cotton.—The variety grown throughout was Allen, of which three selections, Maigana Nos. 1, 5 and 13, were used in the various experiments on the farm.

The crop was picked in very fair condition, but was scarcely as clean and "bright" as last year, chiefly owing to the late rains and slightly increased boll-worm attacks; lint strength however was up to the average, while lint length and ginning percentage show a distinct improvement.

The percentages of the Grades over all the pickings were,

Grade I. 89·5
Grade II. 10·5

Lint length averaged 31·6 mms; this was the average of fifty combings of each picking of each selection and should be reliable.

Ginning percentage averaged 32%.

The highest yield on the farm, on a quarter acre plot, was 556 lb. of seed cotton per acre, and yields all over, excluding one block which was badly waterlogged, are better than last year.

Boll-shedding was fairly general but not very severe, while boll-worm attacks, as mentioned above, were rather above the average.

Groundnuts.—The varieties grown were Zaria, Chinese, American Y, Gambia, Ilorin 2, and Kano.

The crop grew excellently, but yields were very disappointing; the same characteristic as last year, that of producing green leaves until late in the season and not ripening properly until the ground is very hard, was again observed; this makes harvesting costs extremely high.

Possibly earlier planting might alleviate this difficulty.

Guinea Corn.—The yellow (Hausa-Kaura) variety was grown in most cases, though 4¼ acres of the white (Hausa-Farafara) variety were grown for selection work. Yields throughout were lower than last year.

Bulrush Millet.—The local variety (Hausa-Gero), was planted, and was an almost complete failure.

This was due to two causes: firstly to the scarcity of rain in the early part of the growing season and consequent difficulty in getting the crop established, and secondly to the waterlogging of the young plants later in the season, the stands being, according to Native custom, in the furrows between the ridges.

Next season it is proposed to try planting this crop on the sides of the ridges.

Green Manure and Cover Crops.—Mucuna has been universally used as a cover crop this season, and when planted alone has been an excellent crop.

When interplanted among other crops however it has been far less successful, in some cases being nearly a failure.

Mucuna and Dolichos were both tried as early green manure crops and in both cases failed to make sufficient growth. This was not due to any deficiency in Mucuna or Dolichos as green manure crops, but to the lack of a sufficiently long period in which to make growth.

Cowpeas (Wake).—This season cowpeas were sown at the beginning of August which course has been justified by yields of up to 300 lb. of dry threshed beans per acre, and in no case was there an absolute failure.

This is the first time that an actual yield of beans has been obtained from cowpeas on Samaru Farm, owing to too late planting in previous years.

Rice (Swamp). The varieties planted this year were, Maliya, Guiana Creole, and Guiana 75, alternated with Native Swamp Rice.

Yields, although slightly lower than last year, were satisfactory, and in every case the imported varieties were superior to the Native.

Rice (Hill). The test between imported Hill rice and Ilorin rice, was spoilt by the complete failure of both varieties, apparently owing to lack of sufficient water coupled with too late planting; it would appear however that they are not likely to be successful here except under semi-swamp conditions.

Early Green Manuring Experiment.

See Table No. I.

The object of this experiment is to ascertain whether by the digging in of an early green manure crop the fertility of the land for cotton growing can be permanently, or to a great measure, maintained year after year.

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield 7 plots without early green manure ...	483	—
Average difference 6 plots early green manured ...	− 14±37	—

The early green manure was a very light crop and as the land is in good heart it may take two or three years before there are any results of value from this experiment.

Groundnuts—Variety Test.

See Table No. II.

	Yield of unshelled nuts in lb. per acre,	Odds that difference is significant.
Average yield 16 plots under Zaria nuts	614	—
Average difference 3 plots under Chinese nuts	−111±60	30 : 1
Average difference 3 plots under American Y.	+ 29±60	—
Average difference 3 plots under Gambia nuts	− 18±60	—
Average difference 3 plots under Kano nuts	+ 41±60	2 : 1
Average difference 3 plots under Ilorin No. 2 nuts	− 65±60	6 : 1

The results of this test are in some respects the same as those obtained last year, in that Chinese have again yielded badly while Kano have done slightly better than Zaria, but they are not at all conclusive.

A test has also been made of the percentage of shelled to unshelled nuts of the various varieties. *See* Table IIa.

The results of this are very interesting, and tend to indicate that the Ilorin variety are scarcely worth persevering with in the Zaria district, whilst Chinese have their low yield more than balanced by their superior shelling percentage.

Cotton Selection Test.

See Table No. III.

	Yield of seed cotton in lb per acre.	Odds that difference is significant.
Average yield 17 plots Selection 1.	262	—
„ difference 16 plots Selection 5	+ 26±14	30 : 1

The cotton on this block grew excellently and was little if at all affected by waterlogging or other complicating factors. Selection 5 is undoubtedly slightly earlier maturing than Selection 1 ; for other details and comparisons, *see* Table IVa.

Cotton Selection Test.

See Table No. IV.

This experiment, a test between Selections 1, 5 and 13, was laid out without any control plots, so that only apparent results can be recorded.

It is noticed that while Selections 1 and 5 gave similar yields, Selection 13 yielded on the average about 17 lb. per acre more. As regards lint length and ginning percentage all three Selections are remarkably even, (*see* Table IVA) but Selection 5 has the premier place in both respects by a small margin.

Nigerian Rock Phosphate and Cattle Manure Experiment.

This experiment, which is designed to test the manurial value of crushed Nigerian Rock Phosphate, both alone and in combination with farm yard manure, was laid out in two 1 acre blocks each subdivided into thirteen plots, the complete year to year cropping being as follows.

A. Block (Y).	*B Block (Z).*
1st Year 1923 Cotton.	Maize.
(Sown uniformly without manure to test uniformity of the soil).	
2nd Year 1924 Cover Crop (Dolichos) Dug in.	Guinea Corn.
3rd Year 1925 Maize, Cotton, Cowpeas.	Maize, Cotton, Cowpeas.
4th Year 1926 Groundnuts.	Groundnuts.

A. Block (Y). *See* Table No. V.

	Yield of dry threshed Maize in lb. per acre.	Odds that difference is significant.
Average yield of Maize on 7 untreated plots	116	—
Average difference Maize on 2 plots treated F.Y.M. + phosphate	+413±93	100,000 : 1
Average difference Maize on 2 plots treated Phosphate	+202±93	65 : 1
Average difference Maize on 2 plots F.Y.M. + ~~Phosphate~~ ...	+264±93	450 : 1

A. Block (Y). *See* Table No. VI.

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average of cotton from 7 untreated plots	29.4	—
Average difference cotton from 2 plots treated F.Y.M. + phosphate	+ 51±10	∝ : 1
Average difference cotton from 2 plots treated Phosphate ...	+ 12±10	7 : 1
Average difference cotton from 2 plots treated F. Y. M. ~~and Phosphate~~	47±10	∞ : 1

A. Block (Y). *See* TABLE No. VII.

	Yield of cowpeas (dry threshed beans) in lb. per acre.	Odds that difference is significant.
Average yield of cowpeas on 7 untreated plots	9·7	—
Average difference cowpeas on 2 plots treated F.Y.M. + Phosphate ...	+ 18 ± 3·5	∞ : 1
Average difference cowpeas on 2 plots treated Phosphate	+ 36 ± 3·5	∞ : 1
Average difference cowpeas on 2 plots treated F.Y.M. ~~and Phosphate~~ ...	+ 15 ± 3·5	700,000 : 1

It is seen that farm yard manure has, in the case of maize and cotton, given better results than Phosphate, and that farm yard manure and Phosphate have given ~~no~~ better result than farm yard manure alone.

B. Block (Z). *See* TABLE No. VIII.*

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield cotton on 7 untreated plots	39·1	—
Average difference cotton on 2 plots treated F.Y.M.	0 ± 18	—
Average difference cotton on 2 plots treated Phosphate	+ 48 ± 18	250 : 1
Average difference cotton on 2 plots treated F.Y.M. and Phosphate	+ 74 ± 18	50,000 : 1

* *N.B.*—Maize yields were lost in the Samaru fire.

B. Block (Z). *See* TABLE No. IX.

	Yield of cowpeas (dry threshed beans) in lb. per acre.	Odds that difference is significant.
Average yield cowpeas on 7 untreated plots	32	—
Average difference cowpeas on 2 plots treated F.Y.M.	+ 2 ± 9	—
Average difference cowpeas on 2 plots treated Phosphate	+ 14 ± 9	16 : 1
Average difference cowpeas on 2 plots treated F.Y.M. and	+ 38 ± 9	60,000 : 1

Here, with cotton, farm yard manure has not given such a good return as Phosphate, but farm yard manure and Phosphate together give the best return of all; the same thing has occurred with the cowpeas; this bears out last year's result as far as the two manures together are concerned, but the positions of farm yard manure and Phosphate are reversed.

Time of Planting Cotton Experiment.

See Table No. X.

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of cotton on 17 plots planted July 5	224	—
Average difference of cotton on 5 plots planted June 14	+ 23 ± 25	4 : 1
Average difference of cotton on 5 plots planted June 25	+ 9 ± 25	—
Average difference of cotton on 5 plots planted July 15	− 10 ± 25	—

In view of the fact that from previous tests July 5th had been considered the optimum date a repetition of this experiment would seem well worth while.

Cultivation of Cotton Test.

See Table No. XI.

	Yield of seed cotton in lb. per acre.	Odds that difference is significant.
Average yield of cotton on 17 plots with Standard Treatment 1.	292	—
Average difference of cotton on 5 plots with treatment 2.	− 8 ± 42	—
Average difference of cotton on 6 plots with treatment 3.	− 20 ± 39	2 : 1
Average difference on cotton on 5 plots with treatment 4.	− 20 ± 42	2 : 1

Although the result of this experiment is not conclusive it is seen that in each case the cultivations under test showed a decrease and that such being the case there seems no reason for any change unless the alternatives are very much cheaper, and in actual practice they are only very slightly so.

Swamp Rice Variety Test.

See Table No. XII.

	Yield of dry threshed grain per acre.	Odds that difference is significant.
Average yield 13 plots Native Rice	972	—
Average difference 4 plots Maliya Rice	+632 ± 160	25,000 : 1
Average difference 4 plots Guiana Creole Rice	+445 ± 160	340 : 1
Average difference 4 plots Guiana 75 Rice	+ 12 ± 160	—

The yields this year are rather low but this is partially due to the fact that four plots got insufficient water.

For some reason which is not clear, Guiana 75 has not done nearly as well, as in previous years at Ilorin and Samaru.

Poultry.

Pens of pure bred Light Sussex, Indian Game and Rhode Island Red have been maintained throughout the year.

There have not been so many available for distribution as last year owing to a poor breeding season and consequent lack of stock.

The demand for Light Sussex and Rhode Island birds have been considerably in excess of the supply, especially in the case of the first named which are very popular.

Early sales records were lost in the fire but a total of 47 birds has been sold.

The demand for eggs has been fair and a total of 1,194 has been sold during the year.

O. S. SWAINSON,
Superintendent of Agriculture.

TABLE No. I.

Cotton—Early Green Manuring Experiment.

Variety—Allen—Maigana No. 5.

No. of Plot.	Treatment.	Yield of Seed Cotton, lb. per acre.	Increase(+) or decrease(−) compared with mean of adjacent controls.
Block A			
Plot 1	No Green Manure	328 lb.	
,, 2	Early Green Manure	378 ,,	− 30
,, 3	No Green Manure	488 ,,	
,, 4	Early Green Manure	556 ,,	+ 68
,, 5	No Green Manure	488 ,,	
,, 6	Early Green Manure	436 ,,	− 86
,, 7	No Green Manure	556 ,,	
,, 8	Early Green Manure	540 ,,	− 10
,, 9	No Green Manure	544 ,,	
,, 10	Early Green Manure	474 ,,	− 76
,, 11	No Green Manure	556 ,,	
,, 12	Early Green Manure	540 ,,	+ 52
,, 13	No Green Manure	420 ,,	

Each plot ¼ acre. Ridges 4′ apart. Stands of single plants 12″ apart.

Cotton—Sown—July 8, 1925.

Picked.—December 1, 1925.
January 6, 1926.
February 1, 1926.
February 25, 1926.

Mucuna—Sown—May 25, 1925. Turned in before sowing cotton.

Increase (+) or decrease (−) of Plots with Early Green Manure as compared with Plots without.

− 30 lb. per acre.
+ 68 ,, ,, ,,
− 86 ,, ,, ,,
− 10 ,, ,, ,,
− 76 ,, ,, ,,
+ 52 ,, ,, ,,

Average. − 14∓37 lb. per acre.

Root—mean—square—difference between neighbouring control plots 90 lb. per acre.
Cost of cultivation in man days per acre—

TABLE No. II.

GROUNDNUTS—VARIETY TEST.

No. of Plot.	Variety.	Yield of dry unshelled nuts lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block C Plot 1	Native Zaria	952 lb.	
,, 2	,, ,, ...	824 ,,	
.. 3	American	1,008 ,,	+ 204
.. 4	Native Zaria	784 ,,	
.. 5	Gambia	796 ,,	− 11
.. 6	Native Zaria	830 ,,	
.. 7	Kano	736 ,,	− 75
.. 8	Native Zaria	792 ,,	
.. 9	Ilorin 2	700 ,,	− 52
.. 10	Native Zaria	712 ,,	
.. 11	Chinese	708 ,,	+ 108
.. 12	Native Zaria	488 ,,	
.. 13	American	456 ,,	− 28
.. 14	Native Zaria	480 ,,	
.. 15	Gambia	388 ,,	− 52
.. 16	Native Zaria	400 ,,	
.. 17	Kano	548 ,,	+ 110
.. 18	Native Zaria	476 ,,	
.. 19	Ilorin 2	376 ,,	− 156
.. 20	Native Zaria	588 ,,	
.. 21	Chinese	432 ,,	− 206
.. 22	Native Zaria	688 ,,	
.. 23	American	612 ,,	− 88
.. 24	Native Zaria	712 ,,	
,, 25	Gambia	596 ,,	+ 8
,, 26	Native Zaria	464 ,,	
.. 27	Kano	580 ,,	+ 88
,, 28	Native Zaria	520 ,,	
,, 29	Ilorin 2	540 ,,	+ 12
,, 30	Native Zaria	536 ,,	
,, 31	Chinese	300 ,,	− 236
.. 32	Native Zaria	536 ,,	
.. 33	,, ,, ...	424 ,,	

Each plot ½ acre. Ridges 4' apart. Stands 15" apart on both sides of ridges.
All sown, June 9th, 1925. All harvested, November 30th December 4th, 1925.

Increase (+) or decrease (−) of plots of Kano as compared with plots of Zaria.
+ 110 lb. per acre.
− 75 ,, ,, ,,
+ 88 ,, ,, ,,

Increase (+) or decrease (−) of plots of Gambia as compared with plots of Zaria.
− 11 lb. per acre.
− 52 ,, ,, ,,
+ 8 ,, ,, ,,

Increase (+) or decrease (−) of plots of Chinese as compared with plots of Zaria.
+ 108 lb. per acre.
− 206 ,, ,, ,,
− 236 ,, ,, ,,

Average + 41 ± 60 lb. per acre. Average − 18 ± 60 lb. per acre. Average − 111 ± 60 lb. per acre.

Increase (+) or decrease (−) of plots of American as compared with Zaria.
+ 204 lb. per acre.
− 28 ,, ,, ,,
− 88 ,, ,, ,,

Increase (+) or decrease (−) of plots of Ilorin as compared with Zaria.
− 52 lb. per acre.
− 156 ,, ,, ,,
+ 12 ,, ,, ,,

Average + 29 ± 60 lb. per acre. Average − 65 ± 60 lb. per acre.

Root—Mean—Square—Difference between neighbouring controls = 104 lb. per acre.
Cost of cultivation in man days per acre = 176.

TABLE No. IIA.

GROUNDNUTS IN TABLE 2.

VARIETY.	American.	Chinese.	Gambia.	Ilorin.	Kano.	Zaria.
Percentage shelled nuts to unshelled.	65·0	90·0	61·25	52·5	70·0	78·25

TABLE No. III.

Cotton—Selection Test. Allen Cotton.

No. of Plots.	Selection.	Yield of Seed Cotton per acre.	Increase (+) or decrease (−) compared with average of standards.
Block D.			
Plot 1	Selection 1	294 lb.	
„ 2	„ 5	294 „	+ 3
„ 3	„ 1	288 „	
„ 4	„ 5	346 „	+ 86
„ 5	„ 1	232 „	
„ 6	„ 5	264 „	+ 36
„ 7	„ 1	224 „	
„ 8	„ 5	274 „	+ 47
„ 9	„ 1	230 „	
„ 10	„ 5	310 „	+ 17
„ 11	„ 1	356 „	
„ 12	„ 5	278 „	− 39
„ 13	„ 1	278 „	
„ 14	„ 5	258 „	− 41
„ 15	„ 1	320 „	
„ 16	„ 5	324 „	+ 27
„ 17	„ 1	274 „	
„ 18	„ 5	364 „	+ 77
„ 19	„ 1	300 „	
„ 20	„ 5	312 „	+ 34
„ 21	„ 1	256 „	
„ 22	„ 5	292 „	+ 44
„ 23	„ 1	240 „	
„ 24	„ 5	292 „	+ 24
„ 25	„ 1	296 „	
„ 26	„ 5	222 „	− 27
„ 27	„ 1	202 „	
„ 28	„ 5	220 „	+ 24
„ 29	„ 1	190 „	
„ 30	„ 5	284 „	+ 52
„ 31	„ 1	274 „	
„ 32	„ 5	304 „	+ 53
„ 33	„ 1	228 „	

Each plot ¼ acre.
Planted June 30th, 1925.

Ridges 4' apart.
Picked November 25th, 1925.
January 1st, 1926.
February 1st, 1926.
February 22nd, 1926.

Single stands 12" apart.

Increase (+) or decrease (−) of plots of Selection 5 compared to plots of Selection 1.

+524 lb per acre.
−107 „ „ „

Average + 26±14 lb per acre.

Root—Mean—Square—Difference between neighbouring control plots = 58 lb. per acre

Cost of cultivation in man-days per acre = 85

TABLE No. IV.

Cotton—Selection Test.

Variety—Allen.

No. of Plot.	Selection 1. Yield in lb. Seed Cotton per acre.	Selection 5. Yield in lb. Seed Cotton per acre.	Selection 13. Yield in lb. Seed Cotton per acre.
Block D.			
Plot 34	204 lb. per acre ...	...	...
„ 35	...	288 lb. per acre ...	...
„ 36	...	...	268 lb. per acre.
„ 37	312 lb. per acre ...	...	...
„ 38	...	220 lb. per acre ...	...
„ 39	...	...	268 lb. per acre.
„ 40	244 lb. per acre ...	...	...
„ 41	...	242 lb. per acre ...	...
„ 42	...	...	262 lb. per acre.
„ 43	234 lb. per acre ...	...	...
„ 44	...	264 lb. per acre ...	...
„ 45	...	...	300 lb. per acre.
„ 46	252 lb. per acre ...	...	...
„ 47	...	340 lb. per acre ...	...
„ 48	...	...	336 lb. per acre.
„ 49	320 lb. per acre ...	...	...
„ 50	...	284 lb. per acre ...	...
„ 51	...	...	222 lb. per acre.
„ 52	146 lb. per acre ...	...	...
„ 53	...	186 lb. per acre ...	...
„ 54	...	...	236 lb. per acre.
„ 55	280 lb. per acre ...	...	...
„ 56	...	220 lb. per acre ...	...
„ 57	...	...	306 lb. per acre.
„ 58	336 lb. per acre ...	...	...
„ 59	...	304 lb. per acre ...	...
„ 60	...	...	280 lb. per acre.
„ 61	236 lb. per acre ...	...	...
„ 62	...	220 lb. per acre ...	...
„ 63	...	...	276 lb. per acre.
„ 64	220 lb. per acre ...	...	...
„ 65	...	236 lb. per acre ...	...
„ 66	...	...	228 lb. per acre.
Average Yield Seed Cotton in lb. per acre	253·1	254·9	271·1

TABLE No. IVa.

Characteristics of Cotton in Table.

Lint Length.

	First picking.	Second picking.	Third picking.	Fourth picking.	Average.
Selection 1	30·6	32·8	32·3	31·0	31·7
Selection 5	32·2	33·3	32·0	30·3	31·95
Selection 13	31·6	32·4	31·0	30·6	31·4

Ginning Percentages.

	First picking.	Second picking.	Third picking.	Fourth picking.	Average.
Selection 1	31·7	32·1	32·1	31·7	31·9
Selection 5	31·25	31·25	32·6	33·5	32·15
Selection 13	32·6	30·8	30·8	33·3	31·9

TABLE No. V.

Manurial Experiment.

Maize—Nigerian Rock Phosphate and Cattle Manure.

No. of plot.	Treatment.	Yield in lb. of dry threshed maize per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	108 lb. per acre	
„ 2	$N_2 + P_2O_5$	426 „ „	+ 234
„ 3	No Manure	276 „ „	
„ 4	P_2O_5	458 „ „	+ 163
„ 5	No Manure	314 „ „	
„ 6	$N_2 + P_2O_5$	630 „ „	+ 453
„ 7	No Manure	40 „ „	
„ 8	$N_2 + P_2O_5$	636 „ „	+ 592
„ 9	No Manure	48 „ „	
„ 10	P_2O_5	242 „ „	+ 210
„ 11	No Manure	16 „ „	
„ 12	$N_2 + P_2O_5$	88 „ „	+ 76
„ 13	No Manure	8 „ „	

Plots 1/13 acre. Ridges 4′ apart. Stands 1′ apart.

Planted—June 1st, 1925. *Harvested*—October 15th, 1925.

Increase (+) or decrease (−) between plots manured with N_2 and unmanured plots.	Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with $N_2 + P_2O_5$ and unmanured plots.
+ 234 lb. per acre.	+ 163 lb. per acre.	+ 453 lb. per acre.
− 592 „ „ „	+ 242 „ „ „	+ 76 „ „ „
Average + 413±93 lb. per acre.	Average + 202±93 lb. per acre.	Average + 264±93 lb. per acre.

Root—Mean—Square—Difference between neighbouring control. 132 lb. per acre.

Cost of cultivation in man-days per acre = 64.

TABLE No. VI.

Manurial Experiment.

Cotton—Nigerian Rock Phosphate and Cattle Manure.

No. of Plot	Treatment.	Yield in lb. of seed cotton per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	40 lb. per acre	
„ 2	N_2 + P_2O_5	104 „ „	+ 58
„ 3	No Manure	52 „ „	
„ 4	P_2O_5	58 „ „	+ 12
„ 5	No Manure	40 „ „	
„ 6	N_2 + P_2O_5	52 „ „	+ 25
„ 7	No Manure	14 „ „	
„ 8	N_2 + P_2O_5	58 „ „	+ 44
„ 9	No Manure	14 „ „	
„ 10	P_2O_5	32 „ „	+ 12
„ 11	No Manure	26 „ „	
„ 12	N_2 + P_2O_5	92 „ „	+ 69
„ 13	No Manure	20 „ „	

Plots 1/13 acre. Ridges 4′ apart. Single Stands 12″ apart.

Planted—July 8th, 1925. *Picked*—January 19th—February 18th, 1926.

Increase (+) or decrease (−) between plots manured with N_2 + P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with N_2 + P_2O_5 and unmanured plots.
+ 58 lb. per acre	+ 12 lb. per acre	+ 25 lb. per acre
+ 44 „ „ „	+ 12 „ „ „	+ 69 „ „ „
Average + 51 ± 10 lb. per acre.	Average + 12 ± 10 lb. per acre.	Average + 47 ± 10 lb. per acre.

Root—Mean—Square—Difference between neighbouring controls. 14 lb per acre.

Cost of cultivation in man-days per acre = 49.

TABLE NO. VII.

Manurial Experiment—Nigerian Rock Phosphate and Cattle Manure.

Wake—(Cowpeas).

No. of plots.	Treatment.	Yield of dry beans in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Y.			
Plot 1	No Manure	8 lb. per acre.	
2	$N_2 + P_2O_5$	32 „ „	+ 20
3	No Manure	16 „ „	
4	P_2O_5	88 „ „	+ 72
5	No Manure	16 „ „	
6	$N_2 + P_2O_5$	32 „ „	+ 20
7	No Manure	8 „ „	
8	$N_2 + P_2O_5$	24 „ „	+ 16
9	No Manure	8 „ „	
10	P_2O_5	8 „ „	—
11	No Manure	8 „ „	
12	$N_2 + P_2O_5$	16 „ „	+ 10
13	No Manure	4 „ „	

Each plot $\frac{1}{75}$ acre. Ridges 4′ apart. Stands 5′ apart.

Planted—September 4, 1925. *Harvested*—December 22, 1925.

Increase (+) or decrease (−) between plots manured with $N_2 + P_2O_5$ and unmanured plots.	Increase (+) or decrease (−) between plots manured with P_2O_5 and unmanured plots.	Increase (+) or decrease (−) between plots manured with $N_2 + P_2O_5$ and umanured plots.
+20 lb. per acre.	+72 lb. per acre.	+20 lb. per acre.
+16 „ „ „	— „ „ „	+10 „ „ „
Average ±18±3·5 lb. p.a.	Average +36±3·5 lb. p.a.	Average ±15±3·5 lb p.a.

Root—mean—square—difference of neighbouring control plots. 5 lb per acre.

Cost of cultivation in man days per acre = 6.

TABLE No. VIII.

Manurial Experiment– Nigerian Rock Phosphate and Cattle Manure.

Cotton.

No of plots.	Treatment.	Yield of Seed Cotton in lb. per acre.	Increase (+) or decrease (–) compared with mean of adjacent controls.
Block Z.			
Plot 1	No Manure	32 lb. per acre	
2	$N_2+P_2O_5$	130 „ „	+ 103
3	No Manure	22 „ „	
4	P_2O_5	118 „ „	+ 71
5	No Manure	72 „ „	
6	N_2	66 „ „	+ 10
7	No Manure	40 „ „	
8	$N_2+P_2O_5$	84 „ „	+ 46
9	No Manure	36 „ „	
10	P_2O_5	66 „ „	+ 25
11	No Manure	46 „ „	
12	N_2	26 „ „	– 10
13	No Manure	26 „ „	

Plots $\frac{1}{13}$ acre Ridges 4′ apart. Stands of single plants 12″ apart.

Planted July 8, 1925. *Picked* January 19, 1926.
February 18, 1926.

Increase (+) or decrease (–) of plots manured with N_2 compared to unmanured plots.	Increase (+) or decrease (–) of plots manured with P_2O_5 compared to unmanured plots	Increase (+) or decrease (–) of plots manured with $N_2+P_2O_5$ compared to unmanured plots.
+10 lb. per acre.	+71 lb. per acre.	+103 lb. per acre.
–10 „ „ „	+25 „ „ „	+ 46 „ „ „
Average –0±18 lb. p.a.	Average +48±18 lb. p.a.	Average +74±18 lb. p.a.

Root—mean—square—difference between neighbouring controls. 26 lbs. per acre.

Cost of cultivation in man days per acre = 49.

TABLE No. IX.

Manurial Experiment.

Wake (Cowpeas). Nigerian Phosphate and Cattle Manure.

No of plot.	Treatment.	Yield of dry threshed beans in lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block Z.			
Plot 1	No Manure	40 lb. per acre	
2	$N_2+P_2O_5$	88 „ „	+ 48
3	No Manure	40 „ „	
4	P_2O_5	56 „ „	+ 20
5	No Manure	32 „ „	
6	N_2	24 „ „	− 8
7	No Manure	32 „ „	
8	$N_2+P_2O_5$	56 „ „	+ 28
9	No Manure	24 „ „	
10	P_2O_5	40 „ „	+ 8
11	No Manure	40 „ „	
12	N_2	40 „ „	+ 12
13	No Manure	16 „ „	

Plots $\frac{1}{13}$ acre. Ridges 4′ apart. Stands 5′ apart.

Planted—September 4th, 1925. Harvested—December 22nd, 1925.

Increase (+) or Decrease (−) of plots manured with N_2 compared to unmanured plots.	Increase (+) or Decrease (−) of plots manured with P_2O_5 compared to unmanured plots.	Increase (+) or Decrease (−) of plots manured with $N_2+P_2O_5$ compared to unmanured plots
− 8 lb. per acre.	+ 20 lb. per acre.	+ 48 lb per acre.
+ 12 „ „ „	+ 8 „ „ „	+ 28 „ „ „
Average + 2 ± 9 lb. per acre.	Average + 14 ± 9 lb. per acre.	Average + 38 ± 9 lb. per acre.

Root—mean—square—difference between neighbouring controls = 13 lb. per acre

Cost of cultivation in man-days per acre = 6.

TABLE No. X.

Cotton—Date of Planting Test.

Variety—Allen—Maigana No. 1.

No. of Plot.	Date of Planting.	Yield of Seed Cotton, lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block A Bomo			
Plot 1	July 5th, 1925	186 lb. per acre.	
„ 2	June 14th, 1925	246 „ „ „	+ 48
„ 3	July 5th, 1925	210 „ „ „	
„ 4	June 25th, 1925	242 „ „ „	+ 24
„ 5	July 5th, 1925	226 „ „ „	
„ 6	July 15th, 1925	208 „ „ „	+ 18
„ 7	July 5th, 1925	154 „ „ „	
„ 8	June 14th, 1925	238 „ „ „	+ 45
„ 9	July 5th, 1925	232 „ „ „	
„ 10	June 25th, 1925	228 „ „ „	− 4
„ 11	July 5th, 1925	232 „ „ „	
„ 12	July 15th, 1925	180 „ „ „	− 71
„ 13	July 5th, 1925	270 „ „ „	
„ 14	July 5th, 1925	256 „ „ „	
„ 15	June 14th, 1925	248 „ „ „	+ 14
„ 16	July 5th, 1925	212 „ „ „	
„ 17	June 25th, 1925	202 „ „ „	− 31
„ 18	July 5th, 1925	254 „ „ „	
„ 19	July 15th, 1925	290 „ „ „	+ 38
„ 20	July 5th, 1925	250 „ „ „	
„ 21	June 14th, 1925	244 „ „ „	+ 3
„ 22	July 5th, 1925	232 „ „ „	
„ 23	June 25th, 1925	246 „ „ „	+ 24
„ 24	July 5th, 1925	212 „ „ „	
„ 25	July 15th, 1925	240 „ „ „	− 22
„ 26	July 5th, 1925	312 „ „ „	
„ 27	June 14th, 1925	254 „ „ „	+ 7
„ 28	July 5th, 1925	182 „ „ „	
„ 29	June 25th, 1925	210 „ „ „	+ 32
„ 30	July 5th, 1925	174 „ „ „	
„ 31	July 15th, 1925	178 „ „ „	− 13
„ 32	July 5th, 1925	208 „ „ „	
„ 33	July 5th, 1925	134 „ „ „	

Plots ¼ acre. Ridges 4′ apart. Stands of single plants 12″ apart.
Cotton.—Sown on above dates. *Picked.*—December 11, 1925.
January 22, 1926.
February 27, 1926.

Increase (+) or decrease (−) of plots sown on June 14th, compared with plots sown on July 5th.	Increase (+) or decrease (−) of plots sown on June 25th, compared with plots sown on July 5th.	Increase (+) or decrease (−) of plots sown on July 15th, compared with plots sown on July 5th.
+ 48 lb. per acre.	+ 24 lb. per acre.	+ 18 lb. per acre.
+ 45 „ „	− 4 „ „	− 71 „ „
+ 14 „ „	− 31 „ „	+ 38 „ „
+ 3 „ „	+ 24 „ „	− 22 „ „
+ 7 „ „	+ 32 „ „	− 13 „ „
Average + 23 ∓ 25 lb. per acre.	Average + 9 ∓ 25 lb. per acre.	Average − 10 ∓ 25 lb. per acre.

Root—mean—square—difference between neighbouring controls plots 55 lb. per acre.
Cost of cultivation in man days per acre = 93.

TABLE No. XI.

Cotton Cultivation Test.

Variety—Allen—Maigana No. 5.

No. of Plots.	Treatment.	Yield of Seed Cotton in lbs. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls
Block E. Bomo.			
Plot 1 ...	Standard Samaru (1) ...	180 lb. per acre	
,, 2 ...	Weeding (2) ...	248 ,, ,,	+ 25
,, 3 ...	Standard Samaru (1) ...	266 ,, ,,	
,, 4 ...	Native (3) ...	282 ,, ,,	+ 59
,, 5 ...	Standard Samaru (1) ...	180 ,, ,,	
,, 6 ...	Sokoto (4) ...	266 ,, ,,	− 30
,, 7 ...	Standard Samaru (1) ...	412 ,, ,,	
,, 8 ...	Weeding (2) ...	340 ,, ,,	− 51
,, 9 ...	Standard Samaru (1) ...	370 ,, ,,	
,, 10 ...	Native (3) ...	240 ,, ,,	− 98
,, 11 ...	Standard Samaru (1) ...	306 ,, ,,	
,, 12 ...	Sokoto (4) ...	278 ,, ,,	− 49
,, 13 ...	Standard Samaru (1) ...	348 ,, ,,	
,, 14 ...	Weeding (2) ...	268 ,, ,,	− 45
,, 15 ...	Standard Samaru (1) ...	278 ,, ,,	
,, 16 ...	Native (3) ...	270 ,, ,,	+ 8
,, 17 ...	Standard Samaru (1) ...	246 ,, ,,	
,, 18 ...	Sokoto (4) ...	322 ,, ,,	+ 38
,, 19 ...	Standard Samaru (1) ...	322 ,, ,,	
,, 20 ...	Weeding (2) ...	446 ,, ,,	+ 99
,, 21 ...	Standard Samaru (1) ...	372 ,, ,,	
,, 22 ...	Native (3) ...	280 ,, ,,	− 59
,, 23 ...	Standard Samaru (1) ...	306 ,, ,,	
,, 24 ...	Sokoto (4) ...	280 ,, ,,	− 94
,, 25 ...	Standard Samaru (1) ...	442 ,, ,,	
,, 26 ...	Weeding (2) ...	298 ,, ,,	− 68
,, 27 ...	Standard Samaru (1) ...	290 ,, ,,	
,, 28 ...	Native (3) ...	276 ,, ,,	+ 2
,, 29 ...	Standard Samaru (1) ...	258 ,, ,,	
,, 30 ...	Sokoto (4) ...	280 ,, ,,	+ 37
,, 31 ...	Standard Samaru (1) ...	228 ,, ,,	
,, 32 ...	Native (3) ...	162 ,, ,,	− 31
,, 33 ...	Standard Samaru (1) ...	158 ,, ,,	

TABLE No. XI—*continued.*

Plots ¼ acre.	Ridges 4' apart.	Stands.	Single plants 12" apart.
Cotton.	Sown July 10, 1925.	Picked.	December 15, 1925. January 20, 1926. February 25, 1926.

Increase (+) or decrease (−) between plots with cultivation (2) compared with those with cultivation (1).	Increase (+) or decrease (−) between plots with cultivation (3) compared with those with cultivation (1).	Increase (+) or decrease (−) between plots with cultivation (4) compared with those with cultivation (1).
+ 25 lb. per acre.	+ 59 lb. per acre.	− 30 lb. per acre.
− 51 „ „ „	− 98 „ „ „	− 49 „ „ „
− 45 „ „ „	+ 8 „ „ „	+ 38 „ „ „
+ 99 „ „ „	− 59 „ „ „	− 94 „ „ „
− 68 „ „ „	+ 2 „ „ „	+ 37 „ „ „
	− 31 „ „ „	
Average − 8 ± 42 lb. per acre.	Average − 20 ± 39 lb. per acre.	Average − 20 ± 42 lb. per acre.

Root—mean—square—difference between neighbouring control plots -95 lb. per acre.

Cost of cultivation in man days per acre = 91.

TABLE No. XIa.

Approximate Date of operation.	Treatment 1. Standard Samaru.	Treatment 2. Variation on 1.	Treatment 3. Native.	Treatment 4. Sokoto.
June	Ridged	Ridged	Ridged ...	Ridged.
July 1	Plant Cotton ...	Plant Cotton ...	Plant Cotton...	Plant Cotton.
July 15	Hoe	Hoe	Hoe	Hoe.
July 30	„	„	„	„
September 1 ...	Ridge up ...	Ridge up ...	„	Hoe into furrows.
Sept. 30 Oct. 10 ...	Mulch	Weed without disturbing soil	Ridge up ...	Pull earth from furrows to ridges again

TABLE No. XII.

Swamp Rice—Variety Test.

No. of Plots.	Variety.	Yield of dry grain per acre.	Increase or decrease compared with mean of adjacent controls.
Bomo Dam.			
Plot 1	Native	580 lb.	
„ 2	Maliya	1,700 „	+ 850
„ 3	Native	1,120 „	
„ 4	Guiana Creole ...	1,640 „	+ 490
„ 5	Native	1,180 „	
„ 6	Guiana 75 ...	1,200 „	+ 160
„ 7	Native	900 „	
„ 8	Maliya	1,380 „	+ 340
„ 9	Native	1,180 „	
„ 10	Guiana Creole ...	1,680 „	+ 470
„ 11	Native	1,240 „	
„ 12	Guiana 75 ...	1,220 „	+ 50
„ 13	Native	1,100 „	
„ 14	Maliya	2,240 „	+ 1,050
„ 15	Native	1,280 „	
„ 16	Guiana Creole ...	1,440 „	+ 280
„ 17	Native	1,040 „	
„ 18	Guiana 75 ...	920 „	− 180
„ 19	Native	1,160 „	
„ 20	Maliya	1,340 „	+ 290
„ 21	Native	940 „	
„ 22	Guiana Creole ...	1,140 „	+ 540
„ 23	Native	260 „	
„ 24	Guiana 75 ...	480 „	+ 20
„ 25	Native	660 „	

Each plot 1/20th acre. Banks 18″ broad and 9″ apart. Spacings 4″ × 4″ on banks.
All sown—July 6th, 1925. Harvested Native, November 17th, 1925.
Maliya, November 26th, 1925.
Guiana Creole, November 26th, 1925.
Guiana 75, December 4th, 1925.

Increase (+) or decrease (−) of plots of Maliya, compared to plots of Native.	Increase (+) or decrease (−) of plots of Guiana Creole, compared to plots of Native.	Increase (+) or decrease (−) of plots of Guiana 75, compared to plots of Native.
+ 850 lb. per acre.	+ 490 lb. per acre.	+ 160 lb. per acre
+ 340 „ „ „	+ 470 „ „ „	+ 50 „ „ „
+1,050 „ „ „	+ 280 „ „ „	− 180 „ „ „
+ 290 „ „ „	+ 540 „ „ „	+ 20 „ „ „
Average +632 ∓160 lb. p.a.	† Average 445 ∓160 lb. p.a.	Average +12 ∓160 lb. p.a.

Root—mean—square between neighbouring control plots = 320 lb. per acre
Cost of cultivation in man-days per acre = 153.

TABLE No. XIII.

Costs of Cultivation of Main Crops, 1925–26 Season.
in Man-days per acre.

Crop.	Preparation.	Sowing.	After cultivation.	Harvest.	Miscellaneous including guarding.	Total Man days per acre.	
Cotton after Green Manure.	12·9 8·6	6·4 2·7	36·0	27·5	— 3·7	19·3 78·5	97·8
Cotton alone ...	12·0	1·2	43·7	23·8	4·7	85·4	
Groundnuts ...	13·2	2·2	27·5	115·3	17·6	175·8	
Bulrush Millet	2·0	2·9	1·9	1·7	—	8·5	
Guinea Corn and	10·0	1·9	10·3	7·9	1·1	31·2	48·3
Cowpeas.	—	1·5	2·7	4·4	—	8·6	
Cover Crop ...	12·0	8·8	9·2	36·2	—	66·2	

Note:—1. These figures are taken from plots whose cultivation has been normal.

2. Figures for "Cotton after Green Manure" were taken from Block A and allowance made for the fact that only half the plots were Green Manured.

3. Owing to, (A.) Destruction of all records in the fire, (B.) Turning of the farm, these costs, especially "Preparation" and "Sowing" costs should not be relied upon to any great extent. "After Cultivation," "Harvesting," and "Miscellaneous" costs are however reliable.

TABLE No. XIV.

Comparison of Cost of Production and Revenue from Main Crops, 1925-26 Season.

Crop.	Cost in Man-days per acre.	Average yield per acre in lb.	Cost of crop in Man-days per lb.	Assumed Market value per lb. in same condition.	Calculated Return per acre (including transport).	Monetary Return per Man-day.	Condition of Crop.
					£ s. d.		
Cotton (alone)	85·4	267	·32	2d.	2 1 10	5·9d.	Seed Cotton.
Cotton (following early Green Manure).	78·5	476	·16	2d.	3 14 0	11·3d.	Seed Cotton.
Bulrush Millet grown with Guinea Corn and Cowpeas.	8·5	8	1·06	·5d.	0 0 4	·47d.	Grain on head.
	31·2	519	·06	·4d.	0 17 4	6·7d.	Grain on head.
	8·6	33	·26	1·0d.	0 2 9	3·8d.	Threshed beans.
Groundnuts	175·8	614	·29	1·3d.	2 19 3	4·1d.	Undecorticated.

Note.—1. Bulrush Millet (Gero) was an almost complete failure.

2. Average groundnut yields taken from standards *i.e.* Native Zaria.

TABLE No. XV.

Rainfall Record—Samaru 1925.

Month.	Inches of rain recorded.	Number of days on which rain fell.	Average monthly rainfall in inches in Zaria 1904–1925 (inclusive).
January ...	...	...	·0019
February ...	...	...	·0229
March ...	2·39	1	·116
April ...	1·01	3	1·821
May ...	1·97	10	4·232
June ...	7·44	12	6·151
July ...	11·32	10	9·096
August ...	11·35	15	12·190
September	4·70	9	9·368
October ...	3·92	9	1·486
November	·40	1 (estimated)	·029
December	...	...	·097
Totals ...	44·50	70	44·611

ANNUAL, REPORT 1925—KANO AGRICULTURAL STATION, NORTHERN PROVINCES, NIGERIA.

General.

Total area of farm ... ... 160 acres.
Total cultivated area ... ... 148 acres.

Longitude ... 8·30′ E.
Latitude ... 12 N.
Altitude ... 1,600 ft. approx.

Average rainfall over five years 32·81 inches.
Distance from nearest point on coast 500 miles.

Farm Stock.

Twenty-one oxen.
Three cows.

Cropping Notes.

At the beginning of the year labour was extremely scarce, mainly owing to the high wages earned during the groundnut season, and that which was obtainable was of a very inferior and unskilled class, unaccustomed to local methods or local farm tools.

Another point, alluded to in the previous annual report, was that the farm has not yet returned to a uniform state of fertility, and still retains variations traceable to the different native farms which made up its area prior to our occupation in April 1924.

This variation in fertility was especially conspicuous in several of the larger blocks, and somewhat tends to diminish the reliability of results. For example, over the whole farm an average of 254½ lb. per acre of seed cotton was harvested while from one plot M 2 a yield of 780 lb. was obtained, indicating the possibilities of a high average yield if the quality of the soil on the whole farm was uniformly improved.

The crops on the farm, with the exception of cotton, appeared to be slightly below the standard of the surrounding native farms, but this is not surprising when one considers the heavy dressings of manure which are applied to farms in the vicinity, an example which, with the recent purchase of cattle, can be emulated with advantage to the present impoverished soil.

Crop—Maiwa (*Pennisetum Spicetum*).

Maiwa—Time of Planting Test.

See Table No. I.

	Wt. per acre in lb. of heads	Odds that difference is significant.
Average yield of 10 plots sown 10.8.25 (Standard)	330½	—
„ difference 4 plots sown 26.6.25... ...	+ 9±87	—
„ „ „ „ „ 24.7.25... ...	−29±87	—

Mucuna was planted in each plot ten days after the Maiwa. In this block the Maiwa was uneven in growth apart from the fact of various dates of planting. This experiment is being continued with the date of planting ten days earlier, and the Mucuna sown up ten days after the Maiwa. The yield of Maiwa was not satisfactory. The June sowing was affected at first by the lack of rain and soil moisture. There is no significant difference in yields between the three dates of planting.

Crop—Guinea-Corn (*Sorghum Vulgare.*)

Phosphate Experiment.

See Table No. II.

	Wt. per acre in lb. of heads.	Odds that difference is significant.
Average yield 26 plots standard no manure ...	800	—
„ difference 8 plots with Farm yard M. ...	+401±74	∝ : 1
„ „ „ „ „ Rock Phosphate	− 22±74	—
„ „ „ „ „ F. Y. M. and Phosphate	+348±74	∞ : 1

During the whole growing period the plots which had had a dressing of nitrogen were most forward. The heads of guinea-corn formed were also of better quality and better filled. There is no doubt that a nitrogenous dressing has a beneficial effect on this soil.

Groundnut Variety Test.

See Table No. III.

	Wt. per acre in lb. of decorticated nuts.	Odds that difference is significant.
Average yield 26 plots Kano variety	721	—
„ difference 5 plots in Zaria	−209±80	213 : 1
„ „ 5 „ „ Ilorin	−164±80	43 : 1
„ „ 5 „ „ American Y. ...	−228±80	390 : 1
„ „ 5 „ „ Chinese	−251±80	740 : 1
„ „ 5 „ „ Gambia	−251±80	740 : 1

Although the odds that the difference is significant are so large in every case, the fact must be taken into account that the block was in poor 'heart' and some comparatively heavy yields were obtained on plots which had originally been those of a farmer who manured heavily. The groundnuts germinated somewhat unevenly, Chinese and Gambia varieties being by far the poorest with Ilorin and Kano the best. The nuts when harvested were shrivelled in appearance and were altogether a poor sample as compared with others grown locally, even though they had been planted before and harvested after. This block last season was cropped with cotton which may have had an exhaustive effect on the soil. The results, however, show that under the conditions prevailing at the time, Kano variety are superior to the other varieties under observation.

Cotton—Date of Planting Test.

See Table No. IV.

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield 16 plots planted 5.8.25	400¾	—
„ difference 5 plots planted 14.6.25 ...	+162±50	1,720 : 1
„ „ 5 „ „ 25.6.25 ...	+ 76±50	14 : 1
„ „ 5 „ „ 15.7.25 ...	− 6±50	—

The germination was very fair throughout this experiment though owing to drought in early June, the plots planted on the 14th June, 1925, required comparatively more supplying. This block was also affected by variability of fertility otherwise the average yield would possibly have been even higher. The plants in plots 1–20 were vigorous and bolls formed well. Standing water affected plots 21–26. These results are interesting in that a marked superiority in yield is shown in the earliest sown plot, but which, as is noted elsewhere was more affected by cotton stainers.

Cotton—Method of Cultivation Test.

See Table No. V.

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield of 14 plots cultivated by Method 1 =	266	—
„ difference 5 „ „ „ „ 2 =	+29±24	8 : 1
„ „ 4 „ „ „ „ 3 =	+ 8±27	—
„ „ 4 „ „ „ „ 4 =	+ 2±27	—

Method 1 (Standard); the cotton was ridged up about a month before the rains ceased, the second operation being to mulch at the end of the rains.

Method 2. As previous method, ridged up and then at the end weeded without disturbing the soil.

Method 3. Hoeing a month before rains and ridging up at the end.

Method 4. The soil hoed into furrows away from the plants at the time of first operations, and then hoed again later. There is no significant difference in yields between these methods, but it is remarkable that method 2 without mulching gives as good a yield as the other more laborious methods. The cotton germinated fairly and made very fair growth.

Cotton—Strains Test.

Allen No. 1 *v.* Allen No. 5 and Maigana No. 13.

See Table No. VI.

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield of 14 plots Allen No. 1 ...	= 211	—
,, difference 6 ,, ,, ,, 5 ...	= −3·6±24	—
,, ,, 6 ,, ,, (Maigana 13)...	= + 6±24	—

The average yields of this block were disappointing. The germination was good and subsequent growth was fair but patchy. The crop was badly affected at the beginning of the dry weather. There is no significant difference in yields of the three strains under observation.

Cotton—Spacing Test.

Single *versus* double row. Variety Maigana 13.

See Table No. VII.

	Seed Cotton lb. per acre.	Odds that difference is significant.
Average yield of 8 plots single row per ridge	= 257¾	—
Average difference 7 plots double row per ridge	= − 24·5 — ± 64	—

This block was patchy but the average yield is fair. The cotton appeared to be sown rather late but germination and subsequent growth were good. The ridges were 3′ 6″ apart and plants 15″ apart in both cases so that plots with double rows had twice as many plants per acre as the others.

There is no significant difference in yield between those plots planted single and those planted double row.

General three year rotation D. 1st year. Gero, (*Pennisetum Typhoideam*) and Dolichos.

See Table No. VIII.

The average yield of Gero per acre on 20 plots = 474 lb. per acre.
The average yield of Dolichos as hay = 3,608 „ „ „

The Gero, which was planted in eight rows across the 33 ft. wide plot (*i.e.* about 4 ft. 4 ins. apart), was patchy in growth and the average yield does not compare favourably with native farms. Dolichos made good growth and has made excellent hay.

General three year rotation D. 3rd year Gero, Guinea-Corn and Wake (Cowpeas).

See Table No. IX.

The average yield of Gero per acre on 20 plots = 266 lb. per acre.
The average yield of Guinea-corn per acre on 49 plots = 953 lb. per acre.

Gero planted two rows across 33 ft. wide plot. Guinea-corn planted about 2′ 9″ apart. The gero was a poor crop, germination was good but subsequent growth poor and very inferior heads of grain was the result. The guinea-corn was a fair average crop. It did not germinate very well but transplanting was successfully carried out.

Cover Crop and Cotton.

See Table No. X.

Average yield of seed cotton planted 15″ apart 18 plots = 188 lb. per acre.

Mucuna was sown, and dug in, before planting the cotton, but the growth of Mucuna was not heavy. The cotton yield is disappointing as the germination was good but the growth was not sufficient before the rains fell off, at the end of October, to allow for a good plant.

Cotton.

See Table No. XI.

Average yield of seed cotton planted 15″ apart 18 plots = 198 lb. per acre.

Again the germination was fairly good but the plants did not make sufficient growth to give a fair yield.

Maiwa and Mucuna.

See Table No. XII.

Average yield of Maiwa (2 rows across plot) 18 plots = 50 lb. per acre.

Maiwa did not make very good growth, and had to be plentifully supplied. Mucuna germinated well and is now, at the end of the dry season, covering the ground fairly successfully.

Catch Crop Experiment. 1st Year.

See Table No. XIII.

Average yield Guinea-corn 25 plots = 549 lb. per acre.

Gero in this block was a failure due to being planted too late in the season and the heads never filled. Guinea-corn was not a good crop due, no doubt, to the same cause as the failure of Gero. Cowpeas as standard, Dolichos, Mucuna and Canavalia were interplanted in the various plots but they were never successfully established, even though they were supplied plentifully.

Cotton.

See Table No. XIV.

Average yield seed cotton Allen 1, 13 plots = 231 lb. per acre.

Average yield seed cotton Allen 5, 13 plots = 220½ .. .. ..

This block was laid out in double and single rows per ridge and in consequence the experiment had no control plots and the varieties could not be tested against each other. The yield is light, germination was fair.

General three year rotation A. 3rd year. Gero, Guinea-Corn and Wake.

See Table No. XV.

Average weight Guinea-corn 41 plots = 306½ lb. per acre.

Gero was a failure and as the crop never headed out properly the yields are not recorded. The guinea-corn also was a very light crop.

This block is low lying and some of the plots have standing water on them during the rains. Guinea-corn from plots 43-59 and plot 19 were taken to transplant into the remainder of the block as germination was very poor.

Gero, Guinea-Corn and Wake. Cover Crop Experiment.

See Table No. XVI.

Average yield Guinea-corn 17 plots = 450½ lb. per acre.

Maiwa was planted in this block but owing to the lateness of the season was never properly established and no yields were taken. Guinea-corn also suffered apparently from being planted too late and germinated very badly.

MAIWA AND LEGUMES. COVER CROP EXPERIMENT.

See TABLE No. XVII.

Average yield Maiwa 17 plots = 178 lb. per acre.

Mucuna as standard, Dolichos, Cowpeas and Canavalia were planted on this block and all were fairly well established. The Mucuna was the most backward, but Canavalia has withstood the dry season; both Dolichos and Cowpeas have died down.

TABLE No. XVIII.

The Cost of Main Crop in Man-days per acre.

TABLE No. XIX.

Monthly Rainfall and Temperature during the season under review.

TABLE No. XX.

Comparison of Cost of Production and Revenue from Main Crops 1925–26 Season.

J. W. R. PEDDER,
Superintendent of Agriculture.

TABLE No. I.

Maiwa—Time of Planting Test.

No. of Plot.	Date of Planting.	Yield of heads lb. per acre.	Increase or Decrease compared with mean adjacent controls.
Block C.			
1	10th July, 1925	204	
2	26th June, 1925	244	+ 14
3	10th July, 1925	256	
4	24th July, 1925	224	− 32
5	10th July, 1925	256	
6	26th June, 1925	344	+ 52
7	10th July, 1925	328	
8	24th July, 1925	374	−104
9	10th July, 1925	628	
10	10th July, 1925	262	
11	26th June, 1925	236	− 85
12	10th July, 1925	380	
13	24th July, 1925	320	+ 3
14	10th July, 1925	254	
15	26th June, 1925	348	+ 57
16	10th July, 1925	328	
17	24th July, 1925	384	+ 15
18	10th July, 1925	410	

Each plot ¼ acre. Ridges 3′ 6″. Harvested 1st December, 1925.

Increase (+) or decrease (−) of plots sown 26th June as compared with those sown 10th July, 1925.

+ 14 lb. per acre
+ 52 „ „ „
− 85 „ „ „
+ 57 „ „ „

Average +9 ± 87 „ „ „

Increase (+) or decrease (−) of plots sown 24th July, 1925, as compared with those sown 10th July, 1925.

− 32 lb. per acre.
− 104 „ „ „
+ 3 „ „ „
+ 15 „ „ „

Average −29·5 ± 87 lb. per acre.

Root—mean—square—difference between pairs of neighbouring control plots = 73 lb. per acre.

Cost of cultivation = 83 Man-days per acre.

TABLE No. II.

Guinea-Corn. Phosphate Experiment.

No. of Plot.	Treatment.	Yield of heads lb. per acre.	Increase or decrease compared with mean adjacent controls.
Block E (*a*)			
1	No manure (standard) ...	1,260	
2	F.Y.M. at the rate of 1 ton per acre	1,160	+ 70
3	No manure	920	
4	Rock Phosphate P_2O_5 $\frac{1}{2}$ ton per acre	1,090	+ 145
5	No manure	970	
6	F.Y.M. & P_2O_5 at above rates ...	1,420	+ 572
7	No manure	725	
8	F.Y.M. at above rates	1,300	+ 602
9	No manure	670	
10	P_2O_5 at above rates	780	+ 65
11	No manure	760	
12	F.Y.M. & P_2O_5 at above rates ...	1,550	+ 755
13	No manure	830	
14	F.Y.M. at above rates	1,350	+ 285
15	No manure	1,300	
16	P_2O_5 at above rates	1,020	— 205
17	No manure	1,150	
18	F.Y.M. & P_2O_5	870	— 25
19	No manure	640	
20	F.Y.M. at above rates	670	± 0
21	No manure	700	
22	P_2O_5 at above rates	710	— 25
23	No manure	770	
24	F.Y.M. & P_2O_5 at above rates ...	1,080	+ 355
25	No manure	680	
Block E (*b*)			
1	No manure	440	
2	F.Y.M. at above rates	1,520	+1,020
3	No manure	560	
4	P_2O_5 at above rates	960	+ 315
5	No manure	730	
6	F.Y.M. & P_2O_5 at above rates ...	1,360	+ 760
7	No manure	470	
8	F.Y.M. at above rates	1,170	+ 545
9	No manure	780	
10	P_2O_5 at above rates	650	— 150
11	No manure	820	
12	F.Y.M. & P_2O_5 at above rates ...	1,110	+ 390
13	No manure	620	
14	F.Y.M. at above rates	1,020	+ 285
15	No manure	850	
16	P_2O_5 at above rates	660	— 175
17	No manure	820	

TABLE No. II—*continued.*

No. of Plot.	Treatment.	Yield of heads lb. per acre.	Increase or decrease compared with mean adjacent controls.
18	F.Y.M. & P_2O_5 at the rate of $\frac{1}{2}$ ton per acre	680	− 155
19	No manure	850	
20	F.Y.M. at above rates	1,280	+ 400
21	No manure	910	
22	P_2O_5 at above rates	740	− 150
23	No manure	870	
24	F.Y.M. & P_2O_5 at above rates ...	930	+ 135
25	No manure	720	

Plot $\frac{1}{20}$ acre. Ridges 3′ 6″. Sown 13.6.25. Harvested 19.9.25.

Increase (+) or decrease (−) of plots with F.Y.M. as compared with no manure.	Increase (+) or decrease (−) of plots with P_2O_5 as compared with no manure.	Increase (+) or decrease (−) of plots with F.Y.M. and P_2O_5 as compared with no manure.
+ 70 lb. per acre.	+ 145 lb. per acre.	+ 572 lb. per acre.
+ 602 „ „ „	+ 65 „ „ „	+ 755 „ „ „
+ 285 „ „ „	− 205 „ „ „	− 25 „ „ „
+ 0 „ „ „	− 25 „ „ „	+ 355 „ „ „
+1,020 „ „ „	+ 315 „ „ „	− 760 „ „ „
+ 545 „ „ „	− 150 „ „ „	+ 390 „ „ „
+ 285 „ „ „	− 175 „ „ „	− 155 „ „ „
+ 400 „ „ „	− 150 „ „ „	+ 135 „ „ „
Average + 401 ± 74 lb. per acre.	Average + 22 ± 74 lb. per acre.	Average + 348 ± 74 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 208 lb. per acre.

Cost of cultivation = 53 Man-days per acre.

TABLE No. III.

Groundnut Variety Test.

No. of Plot.	Variety.	Yield of dry decorticated nuts per acre.	Increase (+) or decrease (−) compared with mean adjacent control's.
Block K.			
1	Kano standard	924	
2	Zaria	504	− 351
3	Kano	787	
4	Ilorin	632	− 180
5	Kano	838	
6	American Y	430	− 396
7	Kano	815	
8	Chinese	484	− 308
9	Kano	770	
10	Gambia	318	− 488
11	Kano	845	
12	Zaria	608	− 227
13	Kano	828	
14	Ilorin	633	− 125
15	Kano	688	
16	American Y	804	26
17	Kano	960	
18	Chinese	512	− 254
19	Kano	575	
20	Gambia	724	+ 138
21	Kano	600	
22	Zaria	749	+ 123
23	Kano	653	
24	Ilorin	440	− 153
25	Kano	533	
26	American Y	354	− 244
27	Kano	664	
28	Chinese	387	− 314
29	Kano	733	
30	Gambia	318	− 306
31	Kano	511	
32	Zaria	551	− 182
33	Kano	956	
34	Ilorin	715	− 164
35	Kano	802	
36	American Y	494	− 324
37	Kano	834	
38	Chinese	449	− 324
39	Kano	712	
40	Gambia	347	− 331
41	Kano	645	
42	Zaria	292	− 410
43	Kano	760	
44	Ilorin	528	− 200
45	Kano	697	
46	American Y	438	− 156
47	Kano	491	
48	Chinese	386	− 56
49	Kano	394	
50	Gambia	292	− 271
51	Kano	732	

TABLE No. III—*continued.*

Each plot ¼ acre. Ridges 3' 6". Sown 10th–13th July, 1925.

Harvested 11th–20th November, 1925.

Increase (+) or decrease (−) of plots of Zaria as compared with Kano.	Increase (+) or decrease (−) of plots of Ilorin as compared with Kano.	Increase (+) or decrease (−) of plots of American Y. as compared with Kano.
− 351 lb. per acre.	− 180 lb. per acre.	− 396 lb. per acre.
− 227 „ „ „	− 125 „ „ „	− 20 „ „ „
+ 123 „ „ „	− 153 „ „ „	− 244 „ „ „
− 182 „ „ „	− 164 „ „ „	− 324 „ „ „
− 410 „ „ „	− 200 „ „ „	− 156 „ „ „
Average − 209 ± 80 lb. per acre.	Average − 164 ± 80 lb. per acre.	Average − 228 ± 80 lb. per acre.

Increase (−) or decrease (−) of plots in Chinese as compared with Kano.	Increase (+) or decrease (−) of plots in Gambia as compared with Kano.
− 308 lb. per acre.	− 488 lb. per acre.
− 254 „ „ „	+ 138 „ „ „
− 314 „ „ „	− 306 „ „ „
− 324 „ „ „	− 331 „ „ „
− 56 „ „ „	− 271 „ „ „
Average − 251 ± 80 lb. per acre.	Average − 251 ± 80 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 178 lb. per acre.

Cost of cultivation 157 Man-days per acre.

TABLE No. IV.

Cotton Allen 1—Date of Planting Test.

No. of Plot.	Date of Planting.	Yield of seed-cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block M.			
1	5th July, 1925 (Control) ...	400	
2	14th June, 1925	780	+ 303
3	5th July, 1925	545	
4	25th June, 1925	655	+ 147
5	5th July, 1925	472	
6	15th July, 1925	588	+ 35
7	5th July, 1925	634	
8	14th June, 1925	762	+ 143
9	5th July, 1925	605	
10	25th June, 1925	637	+ 61
11	5th July, 1925	548	
12	15th July, 1925	618	+ 79
13	5th July, 1925	530	
14	14th June, 1925	623	+ 208
15	5th July, 1925	301	
16	25th June, 1925	484	+ 154
17	5th July, 1925	359	
18	15th July, 1925	268	− 77
19	5th July, 1925	332	
20	14th June, 1925	493	+ 181
21	5th July, 1925	293	
22	25th June, 1925	158	− 50
23	5th July, 1925	124	
24	15th July, 1925	101	− 35
25	5th July, 1925	148	
26	14th June, 1925	208	− 25
27	5th July, 1925	318	
28	25th July, 1925	405	+ 68
29	5th July, 1925	356	
30	15th July, 1925	367	− 34
31	5th July, 1925	447	

Each plot ¼ acre. Ridges 3′ 6″. Harvested November, 1925 to February, 1926.

Average yield plots sown July 5th. 400 lb. per acre.

Increase (+) or decrease (−) of plots planted, 14th June, 1925, as compared with those planted 5th July, 1925.

+ 303 lb. per acre.
+ 143 „ „
+ 208 „ „
+ 181 „ „
− 25 „ „

Average + 162 ± 50 lb. per acre.

Increase (+) or decrease (−) of plots planted 25th June as compared with those planted 5th July, 1925.

+ 147 lb. per acre.
+ 61 „ „
+ 154 „ „
− 60 „ „
+ 68 „ „

Average + 76 ± 50 lb. per acre.

Increase (+) or decrease (−) of plots planted 15th July as compared with those planted 5th July, 1925.

+ 35 lb. per acre.
+ 79 „ „
− 77 „ „
− 35 „ „
− 34 „ „

Average − 6·4 ± 50 lb. per acre.

Root—mean—square—difference between pairs of neighbouring control plots = 111 lb. per acre.

TABLE No. V.

Cotton—Method of Cultivation Test.

Variety Allen No. 5.

No. of Plot.	Treatment.	Yield of seed-cotton lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Block M.			
32	Method 1 (standard)	311	
33	,, 2	330	+ 40
34	,, 1	270	
35	,, 3	252	− 5
36	,, 1	244	
37	,, 4	212	− 22
38	,, 1	224	
39	,, 2	317	+ 58
40	,, 1	294	
41	,, 3	392	+ 54
42	,, 1	383	
43	,, 4	389	+ 51
44	,, 1	293	
45	,, 2	368	+ 49
46	,, 1	346	
47	,, 3	313	− 34
48	,, 1	349	
49	,, 4	304	− 13
50	,, 1	285	
51	,, 2	255	− 5
52	,, 1	236	
53	,, 3	212	+ 16
54	,, 1	157	
55	,, 4	156	− 9
56	,, 1	173	
57	,, 2	166	+ 2
58	,, 1	156	
59	,, 3	173	Non-experimental

Each plot ¼ acre. Ridges 3′ 6″. Sown 23rd July, 1925. Harvested December, 1925—January, 1926.

Increase (+) or decrease (−) of plots Method 2 as compared with Method 1.	Increase (+) or decrease (−) of plots Method 3 as compared with Method 1.	Increase (+) or decrease (−) of plots Method 4 as compared with Method 1
+ 40 lb. per acre.	− 5 lb. per acre.	− 22 lb. per acre.
+ 58 ,, ,,	+ 54 ,, ,,	+ 51 ,, ,,
+ 49 ,, ,,	− 34 ,, ,,	− 13 ,, ,,
− 5 ,, ,,	+ 16 ,, ,,	− 9 ,, ,,
+ 2 ,, ,,		
Average + 29 ± 24 lb. per acre.	Average + 8 ± 27 lb. per acre.	Average + 2 ± 27 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 55 lb per acre.

TABLE No. VI.

Cotton Strain Test.

Allen No. 1 versus Allen No. 5 and Maigana No. 13.

No. of Plot.	Variety.	Yield of seed cotton lb. per acre.	Increase (+) or decrease (−) compared with mean adjacent control.
Block H.			
26	Allen No. 1	168	
27	Allen No. 5	197	− 22
28	Allen No. 1	270	
29	Maigana 13	227	+ 3
30	Allen No. 1	178	
31	Allen No. 5	196	− 3
32	Allen No. 1	220	
33	Maigana 13	223	+ 24
34	Allen No 1	178	
43	Allen No. 1	249	− 26
44	Allen No. 5	225	
45	Allen No. 1	254	
46	Maigana 13	211	+ 7
47	Allen No. 1	155	
48	Allen No. 5	185	+ 21
49	Allen No. 1	174	− 19
50	Maigana 13	155	
51	Allen No. 1	174	
52	Allen No. 5	182	− 13
53	Allen No. 1	217	
54	Maigana 13	248	+ 15
55	Allen No. 1	250	
56	Allen No. 5	254	+ 21
57	Allen No. 1	217	
58	Maigana 13	238	+ 6
59	Allen No. 1	247	

Each plot ¼ acre. Ridges 3′ 6″. Sown 28th July, 1925.

Harvested December, 1925 to January, 1926.

Increase (+) or derease (−) of plots in Allen 5 as compared with those in Allen 1.

− 22 lb. per acre
− 3 „ „ „
− 26 „ „ „
+ 21 „ „ „
− 13 „ „ „
+ 21 „ „ „

Average − 3·6 ± 23 lb. per acre

Increase (+) or decrease (−) of plots in Maigana 13 as compared with those in Allen 1.

+ 3 lb. per acre
+ 24 „ „ „
+ 7 „ „ „
− 19 „ „ „
+ 15 „ „ „
+ 6 „ „ „

Average + 6 ± 23 lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 56 lb. per acre.

Cost of cultivation = 84 Man-days per acre.

TABLE No. VII.

Cotton Spacing Test single *versus* double row.

Variety Maiganа 13.

No. of Plot.	Treatment.	Yield of seed cotton lb. per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
Block I			
1 and 2	Single row per ridge	206½	
3 „ 4	Double row per ridge ...	262½	+ 64¼
5 „ 6	Single do. do.	189	
7 „ 8	Double do. do.	212½	+ 22½
9 „ 10	Single do. do.	191	
11 „ 12	Double do. do.	181½	+ 11¼
13 „ 14	Single do. do.	149½	
15 „ 16	Double do. do.	133½	− 7¾
17 „ 18	Single do. do.	134	
19 „ 20	Double do. do.	147	− 35
21 „ 22	Single do. do.	230	
23 „ 24	Double do. do.	442	+ 29
25 „ 26	Single do. do.	596	
27 „ 28	Double do. do.	569	+ 87¾
29 „ 30	Single do. do.	366½	
31 „ 32	Double do. do.	376	Non-experimental.

Each plot ¼ acre. Ridges 3′ 6″. Sown 27th July, 1925. Harvested December 1925 to February 1926.

Increase (+) or decrease (−) of plots planted double row per ridge compared with those planted single row per ridge.

+	64¾	lb. per acre.
+	22½	do. do.
+	11¼	do. do.
−	7¾	do. do.
−	35	do. do.
+	29	do. do.
+	87¾	do. do.
Average +	24·5 ± 64	lb. per acre.

Root—mean—square—difference between pairs of neighbouring controls = 168 lb. per acre.

TABLE No. VIII.

GERO, BULRUSH MILLET.

No. of Plot.	Yield of heads in lb. per acre.	No. of plot.	Yield of heads in lb. per acre.
Block A.			
31	516	41	260
32	524	42	292
33	544	43	536
34	576	44	564
35	604	45	456
36	572	46	264
37	704	47	458
38	584	48	392
39	604	49	268
40	440	50	332

Each plot ¼ acre. Ridges 3′ 6″ apart 8 stands per ridge. Sown 17th June, 1925. Harvested 24th September, 1925.

Cost of cultivation plus dolichos for hay plots 31–79 = 68 man-days per acre.

TABLE No. IX.

Bulrush Millet and Guinea Corn.

No. of Plot.	Gero Yield of Heads in lb. per acre.	Guinea Corn Yield of Heads in lb. per acre.	No. of Plot.	Guinea Corn Yield of Heads in lb. per acre.
Block B.			Block B.	
31	248	1,180	51	950
32	300	1,230	52	902
33	388	1,220	53	886
34	368	1,082	54	886
35	352	1,236	55	902
36	328	1,158	56	964
37	244	1,182	57	1,060
38	232	1,084	58	1,100
39	232	1,030	59	1,070
40	260	836	60	946
41	248	910	61	1,044
42	284	810	62	672
43	288	814	63	928
44	344	1,100	64	964
45	304	1,052	65	882
46	260	842	66	856
47	200	748	67	1,090
48	184	716	68	1,258
49	112	470	69	938
50	160	1,072	70	954
			71	878
			72	748
			73	1.140
			74	1,300
			75	1,238
			76	808
			77	760
			78	814
			79	974

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″ apart.

Gero 2 stands per ridge. Sown 13th June, 1925. Harvested 18th Sept. 1925.

Guinea corn. Sown 13th June, 1925. Harvested 20th November, 1925.

Cost of cultivation = 60 man-days per acre.

TABLE No. X.

Cotton—Variety Allen No. 5.

No. of Plot.	Yield of seed cotton lb. per acre.	No. of Plot.	Yield of seed cotton lb. per acre.
Block D.			
1	156	10	135
2	160	11	159
3	150	12	207
4	146	13	232
5	173	14	182
6	132	15	198
7	174	16	222
8	199	17	251
9	231	18	276

Each plot $\frac{1}{4}$ acre. Ridges 3′ ″ apart.
Cotton sown 28th July, 1925. Harvested December 1925 to January 1926.
Cost of cultivation 89·5 man-days per acre.

TABLE No. XI.

Cotton—Variety Allen No. 1.

No. of Plot.	Yield of seed cotton lb. per acre.	No. of plot.	Yield of seed cotton lb. per acre.
Block F.			
1	306	10	189
2	234	11	216
3	288	12	164
4	284	13	96
5	265	14	77
6	285	15	69
7	279	16	81
8	239	17	107
9	187	18	194

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″ apart.
Cotton sown 29th July, 1925. Harvested January 1926.
Cost of cultivation = 89·2 man-days per acre.

TABLE No. XII.

Maiwa.

No. of plot.	Yield of Heads lb. per acre.	No. of plot.	Yield of Heads lb. per acre.
Block G.			
1	21	10	38
2	16	11	48
3	37	12	64
4	58	13	60
5	68	14	60
6	58	15	66
7	62	16	48
8	32	17	70
9	42	18	56

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″ apart.
Maiwa 2 stands per ridge. Sown 30th June 1925. Harvested 8th December, 1925.
Cost of cultivation 54 man-days per acre.

TABLE No. XIII.

Guinea Corn

No. of Plot.	Yield of Heads lb. per acre.	No of Plot.	Yield of Heads lb. per acre.
Block H.			
1	952	14	476
2	612	15	616
3	562	16	624
4	634	17	516
5	734	18	538
6	652	19	654
7	704	20	591
8	501	21	559
9	424	22	470
10	366	23	481
11	364	24	421
12	366	25	534
13	370		

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″ apart.
Guinea corn. Sown 19th June, 1925. Harvested 9th December, 1925.
Cost of Cultivation—Gero. Guinea corn and various Legumes = 66 man-days per acre.

TABLE No. XIV.

Cotton Varieties Allen 1 and Allen 5.

No. of plot.	Variety.	Yield of seed cotton lb. per acre.	No. of plot.	Variety.	Yield of seed cotton lb. per acre.
Block I.					
34	Allen 1 Single row	333	47	Allen 5 Double row	225
35	Allen 1 Double „	381	48	Allen 1 Double „	280
36	Allen 5 Double „	409	49	Allen 5 Single „	208
37	Allen 5 Single „	264	50	Allen 1 Single „	239
38	Allen 1 Single „	210	51	Allen 5 Double „	248
39	Allen 5 Double „	247	52	Allen 1 Double „	278
40	Allen 1 Double „	192	53	Allen 5 Single „	182
41	Allen 5 Single „	156	54	Allen 1 Single „	173
42	Allen 1 Single „	155	55	Allen 5 Double „	211
43	Allen 5 Double „	227	56	Allen 1 Double „	183
44	Allen 1 Double „	220	57	Allen 5 Single „	83
45	Allen 5 Single „	286	58	Allen 1 Single „	113
46	Allen 1 Single „	251	59	Allen 5 Double „	120

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″.

Cotton sown 27th July, 1925. Harvested December 1925 to February, 1926.

TABLE No. XV.

General 3 Year Rotation A.

Guinea Corn.

No. of Plot.	Yield of Heads lb. per acre.	No. of Plot.	Yield of Heads lb. per acre.
Block N.			
1	492	22	252
2	316	23	320
3	274	24	336
4	340	25	250
5	480	26	156
6	636	27	184
7	534	28	152
8	298	29	182
9	316	30	226
10	352	31	160
11	520	32	86
12	374	33	114
13	288	34	110
14	332	35	190
15	422	36	150
16	450	37	254
17	384	38	406
18	458	39	454
19	—	40	376
20	186	41	342
21	170	42	248

Each plot ¼ acre. Ridges 3' 6" apart.

Guinea corn sown 15th June, 1925. Harvested 4th December, 1925.

Cost of cultivation Gero. Guinea corn and Wake plots 1–59 = 71 M.D.P.A.

TABLE No. XVI.

Guinea Corn.

No. of Plot.	Yield of Heads lb. per acre.	No. of Plot.	Yield of Heads lb. per acre.
Block P.			
26	443	35	366
27	630	36	324
28	552	37	192
29	915	38	310
30	491	39	550
31	300	40	500
32	351	41	608
33	328	42	480
34	318		

Each plot ¼ acre. Ridges 3' 6".

Guinea corn (Variety—Farafara) sown 16th June and 17th July, 1925. Harvested 10th December, 1925.

Cost of cultivation = 48 man-days per acre.

TABLE No. XVII.

MAIWA.

No. of Plot.	Yield of Heads lb. per acre.	No. of Plot.	Yield of Heads lb. per acre.
Block P.			
43	236	51	132
44	138	52	240
45	128	53	282
46	132	54	208
47	114	55	228
48	116	56	184
49	126	57	226
50	156	58	198
		59	188

Each plot $\frac{1}{4}$ acre. Ridges 3′ 6″ apart.

Maiwa 2 stands per ridge, sown 17th July, 1925. Harvested 4th December, 1925.

Cost of cultivation=53 Man-days per acre.

TABLE No. XVIII.

COST OF MAIN CROPS IN MAN-DAYS PER ACRE.

Crop.	Preparation.	Planting.	Cultivation.	Harvest.	Miscellaneous.	Total.
Cotton	23	13	39	21	2	98
Groundnuts ...	20	7·6	50·5	76·5	4·4	157
Gero, Guinea corn and Wake ...		10	36	12	—	58

TABLE No. XIX.

Monthly Rainfall and Temperature.

Month.	Rainfall in inches.	No. of days on which rain fell.	Average fall over 6 years.	Mean temperature.	Mean temperature over 5 years.
January	Nil	...	...	63·9	69·6
February	Nil	...	...	72·5	75·7
March	1·03	2	0·17	85·6	83·4
April	·70	1	0·49	88·3	89·2
May	2·41	9	1·45	88·2	88·2
June	2·71	3	3·39	83·3	83·7
July	11·45	13	8·15	79·5	79·7
August	13·61	15	13·47	77·0	77·2
September ...	5·29	9	5·90	79·9	79·7
October	2·20	4	0·81	81·2	80·6
November ...	Nil	...	...	78·9	77·9
December ...	Nil	...	...	70·3	71·7
Total ...	39·40	56	33·83	...	...

TABLE No. XX.

Comparison of cost of Production and Revenue from Main Crops, 1925–26 Season.

Crop.	Cost in Man-days.	Average yield per acre in lb.	Cost of Crop in Man-days per lb.	Assumed market value per lb.	Calculated Return per acre (including transport to market).	Monetary Return per Man-day.	Nature of Crop.
					£ s. d.		
Cotton (following Bulrush Millet)	84	211	0·39	3·0d.	2 11 9	7·3d.	Seed Cotton.
Cotton (following early Green Manure) ...	89·5	188	0·47	3·0d.	2 5 6	6·1d.	Seed Cotton.
Bulrush Millet with	...	266	...	0·6d.	0 12 0		
Guinea-corn and Cowpeas	60	988	...	0·6d.	1 19 4	10d.	Unthreshed.
Ground-nuts	157	610	0·25	1·2d.	2 16 0	4·2d.	Decorticated.

ANNUAL REPORT, MAIGANA SEED FARM, 1925.

The physical features of the station are :—

(1). Latitude ... 11 North.

(2). Longitude ... 8 East.

(3). Altitude .. 2,200 ft. above sea level.

2. *Rainfall. Table No. I.*—Only the number of days on which rain fell can be given as there was no rain gauge on the station.

3. The rains were late in starting, and the early crops—Millet and Guinea corn, were planted later than usual. The latter crop was not affected to any extent, but the former, in spite of several plantings, failed to make good. The season, nevertheless might be considered generally as a favourable one, for the rains—apart from being evenly distributed—held out fairly well into October, and the harmattan, appearing later than last season, was not severe.

4. *Treatment of Land* :—This was confined chiefly to the raising of Mucuna early in the season and digging it in before planting. The scheme was adopted to ascertain whether it will be practicable to maintain the fertility of the soil without depending on cattle manure which has, of late, become difficult to obtain. One year's trial of Mucuna seems to justify its use as a green manuring crop and the cost of raising it is almost the same per acre as cattle manure applied at the rate of three tons per acre.

5. *Cotton* :—*Table No. II.* Fifty-eight acres were grown of the three best strains, *i.e.* Nos. 1, 5 and 15. An experiment was arranged on Block A to ascertain the relative value of green manure (Mucuna) as opposed to cattle manure, and four plots, $2\frac{1}{2}$ acres each—two manure and Mucuna and two Mucuna alone—were devoted to this experiment. Cultural operations were the same for all plots. The Mucuna grew slowly during the early stages of growth, and mole crickets did a fair amount of damage to the young plants. After the rains had set in however, growth was rapid, the ground was soon covered, and a good green crop was ultimately turned in. The results, as recorded in Table No. II, show only a slightly increased return from the Mucuna plus manure plots. It is intended to continue this experiment for some

time before drawing final conclusions, as there may be some residual value as far as Mucuna plus manure is concerned. Mucuna was also dug into blocks B, C, and F with good results.

6. *Yields* :—The average yield per acre for the total crop of fifty-eight acres is 412 lb. of seed-cotton as compared with 287 last season, an increase of 43·6 per cent. The highest yield was 611 lb. obtained from an acre grown from 300 bulked selections. Whilst fairly heavy yields of seed-cotton have been obtained, the ginning percentage of lint has not increased.

Individual Selections :—Thirty individual selections made in 1924 from Strains Nos. 5, 13, 15 and 16, were planted out in small plots which were surrounded by maize. They were not "selfed" however. The record of each plant is kept but is not shown here. Examination of lint characters shows that the bulk of the progenies of each parent plant have come up to standard. They are to undergo further trial next season.

Seed Distribution. Table No. V :—The total amount of improved seed distributed from this centre during the season was 40,656 pounds or roughly eighteen tons, to 1,065 farmers. This covered approximately 1,895 acres. From this area a crop of little over 150 tons was purchased by the British Cotton Growing Association at Awai between December 1925 and March 1926.

7. *Guinea Corn, Millet and Cowpeas. Table No. III* :—Millet was grown as a catch crop, but owing to lack of good early rains was not a success. Five acres of "Kaura" and five of "Farafara" were grown as a main crop on block D and ½ acre of "Kaura" and "Farafara" respectively, selections, on block H. Fairly good yields were obtained. Over 500 selections were made.

Cowpeas "Wake" (Hausa) were interplanted in the Guinea corn after the Millet was removed. 300 pounds of dried beans were harvested.

8. *Groundnut—Varieties. Table No. IV* :—Seven varieties were grown chiefly to maintain the seed. The yields obtained were quite good. The variety "Chinese" continues to improve in yield yearly.

9. *Maize. Table No. VII*:—The varieties "Ibadan" Creole and "Maigana" Native were grown. The Maigana "Native" continues to yield higher than the "Ibadan" Creole although the latter has been in cultivation for the past three years. Over one hundred cobs of Creole maize were sold to natives for sowing next season.

10. *West-Indian Tannia and Eddo. Table No. 6* :—This crop is still grown for distribution to farmers. The natives around Maigana, Kinkibba, Awai and Gimba villages are raising fair crops of both varieties which are readily saleable in the local markets at a higher price than the native tuber, known locally as "Gwaza."

11. *Cover Crop* :—One ten-acre block "E" was put under Mucuna for a whole season and the seed allowed to ripen off. The haulmes were subsequently fed to cattle which were confined to the block for the purpose of kraaling. The cattle owned by "Fulani" thoroughly relished the partially dried Mucuna, and so thoroughly was the block picked of the Mucuna fodder that it was difficult to realise that such a crop was grown on it. The crop needed little attention and was consequently cheaply raised. A return of 445 lb. of cleaned seed was obtained per acre.

12. *Miscellaneous Crops* :—A number of other crops of minor importance have been grown, *i.e.* West Indian Sugar Canes, Elephant Grass and Guinea Grass. Fifty canes were supplied to the Resident, Muri, *via* Jos for distribution to natives of that district.

A. H. S. VIGO,

Senior Overseer in Charge.

TABLE No. I.

Rainfall Record.

Month.	Days of Rainfall.
January	—
February	—
March	—
April	4
May	6
June	9
July	11
August	17
September	13
October	6
November	—
December	—
	66 days.

TABLE No. II.

Cotton Yields.

Block.	Plot.	Selection number.	Acreage.	Treatment.	Yield per acre in lb. Seed-cotton.	Ginning % lint.	Average lint length.
A	1	15	2½	300 cattle-nights per acre kraaling and early Mucuna ...	460·4	28%	32.m.m.
A	2	15	2½	Mucuna alone ...	461·2	„	„
A	4	15	2½	300 cattle-nights per acre kraaling and early Mucuna ...	407·6	„	„
A	3	15	2½	Mucuna alone ...	352·0	„	„
				Average yield 2 plots cotton treated with kraaled manure and mucuna. 434 lb per acre.			
				Average yield 2 plots cotton treated with Mucuna alone 406·6 lb p.a.			
				Difference Mucuna and Manure plots over Mucuna alone plots = 27·4 lb p.a. = 6·7 %.			
B	...	15	5	Early Mucuna ...	439·2	28·00	32.m.m.
B	...	1	5	do. ..	354·8	„	32. „
C	...	1	10	do. ...	404·9	27·39	30. „
F	...	1	10	do. ...	300·4	„	30. „
G	...	5	10	1,000 cattle-nights per acre kraaling ...	472·8	27·34	33. „
H	...	5	6	3 do. ...	493·6	27·34	33. „
H	10	M 1	1	3 do. ...	611·0	29·41	33. „

(1) Cost of cultivation in man-days per acre = 73.

(2) Date of planting from July 9th—July 14th, 1925.

(3) Date of harvesting from 14th December, 1925—18th February, 1926.

(4) Average yield per acre over 58 acres 412·8 lb of seed-cotton.

(5) M. 1 = Bulked selections, 1924.

TABLE No. III.

GUINEA CORN AND GERO—MAIN CROP.

Block.	Plot.	Variety.	Acreage.	Yield per acre unthreshed in lb.	Remarks.
D	—	Gero	10 acres	75·3	Planted from selected seed.
D	—	Kaura	5 „	1,515·6	Planted from bulked selections 1924.
D	—	Farafara	5 „	970·4	do.
H	5	Kaura	½ acre	1,786	Planted from individual selections 1924. (Bulked).
H	8	Farafara	½ „	1,564	do.

(1) Cost of cultivation of Gero in man-days per acre = 18.
„ „ Guinea corn „ „ = 51.
(2) Date of planting Gero 7/5/25 Guinea corn 21/5/25.
(3) Date of harvesting Gero from 14–17/8/25.
„ „ Guinea corn 26–30/11/25.

TABLE No. IV.

GROUNDNUT—SELECTED VARIETIES.

Block.	Plot.	Variety.	Acreage.	Yield per acre undecorticated in lb.	Remarks.
H	2	Ilorin 2 ...	11/162	1,413·	Planted from selected individual plants and bulked for planting.
H	2	Native Zaria	„	1,590·6	
H	2	Chinese ...	„	1,237·	
H	2	Ilorin 22 ...	„	1,237·	
H	2	Dixie Giant	10/162	842·4	
H	2	Kano ...	11/162	1,502·2	
H	2	Gambia ...	10/162	1,425·6	

(1) Cost of cultivation in man days per acre = 114
(2) Date of planting 13/6/25.
(3) Date of harvesting 19/11/25

TABLE No. V.

Special Cotton Seed Distribution, 1925.

Number of Farmers.	Weight of seed distributed in 1925 lb.	Average seed weight per farmer lb.	Approximate acreage sown in 1925.	Average acreage per farmer.	Approximate weight of seed cotton purchased in 1925 26 lb.	Equivalent seed weight lb.	Average seed return per farmer lb.	Ratio of seed returned to seed given out.
1,065	40,656 (18 tons) approximate.	38	1,895	1·8	336,000 (150 tons) approximate.	224,000 (100 tons) approximate.	210	5·5 : 1

(1) Seed grown in selected areas around Maigana Farm *i.e.* Maigana, Gimba, Awai and Saibu Villages, and purchased by B. C. G. A. at Awai between 15/12/25–31/3/1926.

TABLE No. VI.

West Indian Tannias and Eddoes.

Block.	Plot.	Variety.	Acreage.	Yield per acre.	Remarks.
1	1	Tannias ...	$\frac{1}{6}$ acre ...	7,020	
1	1	Eddoes ...	$\frac{1}{3}$ acre ...	1,665	Bad germination accounts for poor return.

(1) Cost of cultivation in M.D.P.P. = 136.

(2) Date of planting 30th May, 1925. Harvesting done 23rd March, 1926.

TABLE No. VII.

Maize—Selections.

Block.	Plot.	Variety.	Acreage.	Yield per acre.	Remarks.
H	5	Ibadan "Creole" ...	$\frac{1}{4}$ acre	1,800	Planted from selected seed.
H	8	Maigana "Native"...	$\frac{1}{4}$ acre	2,104	do.

(1) Cost of cultivation in M.D.P.A. = 88.

(2) Date of planting Ibadan "Creole" 13th June, 1925. Harvesting 16th October, 1925.

(3) Date of planting Maigana "Native" 3rd June, 1925. Harvesting 25th September, 1925.

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This farm is situated about five miles to the south-west of Benin on what was formally a Forest Reserve. It is about 300 acres in extent.

The soil is red and may be described as a light sandy loam with free drainage. There is hardly any covering of humus even as one approaches the stream.

Previous to 1925 cocoa and oil palms had been planted chiefly in rides cut in the existing bush. It was then decided to lay out a series of experiments to investigate certain points of an agricultural and economic nature likely to be met with by the farmer wishing to lay out a plantation.

Several of these experiments will go on for a period of years in order that conclusive results may be obtained.

PERMANENT CROPS.

I.—Cocoa.

Experiment 1. To test the merits of plantains against pigeon pea, cassava and maize followed by beans, respectively, as temporary live shade for young cocoa.

The plantains have not grown sufficiently to be of service this year.

Experiment 2. To establish blocks of cocoa from seed from trees of known bearing qualities—not necessarily high qualities.

Experiment 3. To compare (*a*) earth mulched, (*b*) leaf mulched plots against those in which the bush is kept cut back.

Experiment 4. To find out at what regular intervals of time bush must be cut back in order to kill it out before it it interferes with the cocoa.

II.—Oil Palms.

Experiment 1. To test the effect on the yield of farm crops of the presence of varying numbers of oil palms per acre growing in the farms.

This method of establishing a plantation is adopted sometimes in the case of cocoa and seems a likely method for a farmer wishing to establish an Oil Palm Plantation. Over a series of years very useful information should be gained. Two year old oil palms at thirty-three and twenty-one trees per acre respectively appear to have had no effect this year on the inter-crop yams.

Experiment 2. To establish a plantation of Oil Palms from seeds of trees at Calabar known to have yielded heavily for at least three years (over 2 cwt. fruits per tree per annum.)

Experiment 3. To give an exhaustive test as cover crop in palm land to a very persistent wild bean found at Ogba which has remained green for at least two years and gives a good bulk of material.

III.—Cocoa and Palms.

Annual crops.

A mixed plantation has been established. Experiments with these crops are laid down chiefly to obtain some definite information about points arising from attempts to supplant "shifting" cultivation, as now practised, by "continuous cropping," without impoverishing the soil. As this depends a good deal on green manures at frequent intervals, the following experiments are included :—

Experiment 1. To test the respective merits of Dolichos, Mucuna, Crotolaria and a local wild bean as green manure preceding early maize.

Experiment 2. To study the effect upon the fertility of the soil of :—

(*a*) a maize crop

(*b*) a cassava crop.

Experiment 3. To ascertain the limits of the season for the profitable growing of maize. *See* Table V.

Experiment 4. To ascertain the limits of yam planting season.

In the neighbourhood of Benin a limiting factor as regards earliness of planting of yams is the presence of a large brown night-flying beetle of the genus *Prienerorycte*s. Its life history seems to be unknown at present. The crops tubers obtained from yams grown during the season when this beetle is found on the wing are so much attacked as to be unsaleable. This pest attacks white, yellow and water yams.

	lb per acre.	Odds.
Average yield 7 plots of yams planted May 1–3	6,863	
„ difference 2 plots of yams planted Mar. 15	+3,141 ± 802	33,000 : 1
„ „ 2 „ „ „ „ April 1	− 633 ± 802	4 : 1
„ „ 2 „ „ „ „ „ 15	−1,017 ± 802	8 : 1

It will be seen that as regard weight per acre plots planted in March are definitely superior under the conditions named. Early planting also secures an ample supply of seed for next year's farms. March planted yams are, however, so damaged by beetle as to be almost uneatable. May planted yams are practically undamaged.

The very definite problem—how to control this yam beetle—therefore lies before us. This pest is at its worst from about mid-April to early May. Immediate steps have been taken to learn the life history of this beetle. *See* Table II.

Experiment 5. To compare over a period of years and on different soils plots farmed by local men on their own lines exactly, as against two sets of plots (1) stumped (2) unstumped which are farmed continuously but in which the density of crops planted per acre is the same as that in the native farms. These experimental plots are ridged. 1925 is the first year of this experiment.

The only minor crop planted was corn and this on so small a scale as to be negligible.

The farmers refused to plant other minor crops as they consider that was women's work. Women were not obtainable. It is hoped to overcome the men's prejudice in the repeated experiment this year. The numbers of yams planted on each plot were the same, viz. an average of 440 seed yams. This seems a very uneconomical density.

	Yield of yams lb. per acre.	Odds.
Average yield 9 plots farmed on native lines	6,490	
„ difference 4 plots stumped and ridged at 6′	−505 ± 641	4 : 1
„ „ 4 „ unstumped and ridged at 6′	− 37 ± 641	—

See Table III.

Future requirements in building materials have been anticipated by planting :—

Raphia Palm (Nipa Palm failed) for roofing leaves.
"Ebony" for roofing leaves.
Bamboos and Calamus (for cane.)

S. M. GILBERT,
Superintendent.

TABLE No. I.

Maize—Time of Planting Experiment.

Plot.	Date sown.	Lb. dry cobs per acre.	Plots.	Date sown.	Lb. dry cobs per acre.	Plot.	Date sown.	Lb. dry cobs per acre.
Y 31		2,372	32		1,424	33		
37	March 18, 1925	2,360	38	April 18, 1925	1,282	39	May 18, 1926	Failed
43		2,188	44		1,256	45		
49		1,820	50		1,172	51		
Average ...		2,185			1,283			

TABLE No. II.

Yams. Time of Planting Test.

Plot No.	Date of sowing.	Yield of edible yams lb. per acre.	Yield of Seed yams lb. per acre.	Total yield lb. per acre.	Increase (+) or Decrease (−) compared with mean of adjacent controls.
Z 46	May 1—4 ...	4,584	1,120	5,704	
47	March 15 ...	6,248	3,784	10,032	+ 4,470
48	May 1—4 ...	4,168	1,252	5,420	
49	April 1 ...	4,080	2,528	6,608	+ 284
50	May 1—4 ...	5,752	1,476	7,228	
51	April 15 ...	3,384	2,344	5,728	− 2,190
52	May 1—4 ...	6,592	2,016	8,608	
53	March 15 ...	6,616	3,492	10,108	+ 1,812
54	May 1—4 ...	6,608	1,376	7,984	
55	April 1 ...	3,512	2,464	5,976	− 1,550
56	May 1—4 ...	5,708	1,360	7,068	
57	April 15 ...	4,380	2,324	6,704	+ 156
58	May 1—4 ...	4,780	1,248	6,028	

¼ acre plots—Ridges 6' apart—2' apart on ridge.

Increase (+) or decrease (−) of plots sown March 15th, 1925 as compared with plots sown May 1—4.	Increase (+) or decrease (−) of plots sown April 1st, 1925 as compared with plots sown May 1—4	Increase (+) or decrease (−) of plots sown April 15th, 1925 as compared with those sown May 1—4, 1925.
+ 4,470 lb. per acre.	+ 284 lb. per acre.	− 2,190 lb. per acre.
+ 1,812 „ „ ..	− 1,550 „ „ ..	+ 156 „ „ ..
Average + 3,141 ± 802 lb. per acre.	Average − 633 ± 802 lb. per acre.	Average − 1,017 ± 802 lb. per acre.

Root—mean-square—difference between pairs of neighbouring controls = 1,122 lb. per acre.

TABLE No. III.

Continuous Cropping Experiment.

No. of Plot.	Treatment.	Crop.	Yield of yams lb. per acre.	Increase (+) or decrease (−) compared with mean of adjacent controls.
Y 80	Native Practice ...	Yams	5,188	
81	Continuous Cropping (stumped)	„	4,656	− 1,292
82	Native Practice ...	„	6,708	
83	Continuous Cropping (unstumped)	„	5,324	− 1,634
84	Native Practice ..	„	7,208	
85	Continuous Cropping (Stumped)	„	5,100	− 1,626
86	Native Practice ...	„	6,244	
87	Continuous Cropping (unstumped)	„	6,896	+ 1,240
88	Native Practice ...	„	5,068	
89	Continuous Cropping (stumped)	„	7,336	+ 1,326
90	Native Practice ...	„	6,952	
91	Continuous Cropping (unstumped)	„	7,984	+ 520
92	Native Practice ...	„	7,976	
93	Continuous Cropping (stumped)	„	7,288	− 430
94	Native Practice ...	„	7,460	
95	Continuous Cropping (unstumped)	„	6,260	− 274
96	Native Practice ...	„	5,608	

Each plot = ¼ acre.

Increase (+) or decrease (−) of plots ridged and stumped as against native farming practice.

− 1,292 lb. per acre.
− 1,626 „ „ „
+ 1,326 „ „ „
− 430 „ „ „

Average − 505 ± 641 lb. per acre.

Increase (+) or decrease (−) of plots ridged but unstumped as against native farming practice.

− 1,634 lb. per acre.
+ 1,240 „ „ „
+ 520 „ „ „
− 274 „ „ „

Average − 37 ± 641 lb. per acre.

Root—mean—square—difference between neighbouring control plots = 1,282 lb. per acre.

TABLE No. IV.

Rainfall 1925.

Experimental Farm, Ogba.

Months.	Rainfall in inches.	Months.	Rainfall in inches.
January	...	July	11·97
February	1·29	August	15·08
March	6·02	September ...	10·93
April	4·23	October ...	9·19
May	4·89	November ...	3·20
June	8·58	December ...	·24
		Total ...	75·66

Average rainfall for three years from 1923–25 inclusive = 69·23.

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The year 1925 has been one of the wettest on record. The rainfall for the year has been as follows :—

	1925.	1926.
January ...	0·00 inch.	0·00 inch.
February ...	0·07 „	1·03 „
March ...	1·88 „	0·82 „
April	0·93 „	
May	5·91 „	
June	11·31 „	
July	7·25 „	
August ...	12·81 „	
September ...	18·01 „	
October ...	5·76 „	
November ...	0·77 „	
December ...	0·00 „	
Total ...	64·70 inches.	

The average for the last 21 years is 50·39 inches.

Cotton.

During the months of August and September some of the land on which cotton was growing became so wet that the cotton was either killed outright or stunted to such an extent that the results are of little value. This is especially the case in block D where more than half the plots were spoilt.

Experiments have been carried out with cotton over as wide a range of conditions as it was possible—as a sole crop on the richest and poorest soils, in combination with groundnuts on poor and on fairly rich land and in combination with yams on a rather poor soil. The cotton returns are generally very low both on the Government Farm and throughout the Province.

Cotton Variety test on rich Soil.

Ilorin Native *v.* Allen sown July 15 *v.* Allen sown Aug. 15.

(Table No. I).

	lb. per acre.	Odds that difference is significant.
Average yield 10 plots Native ...	196	—
Average difference 4 plots Allen, July 15	− 84±32·1	213 : 1
Average difference 4 plots Allen, August 15	−128±32·1	33,000 : 1

It is evident under the conditions of the experiment that Ilorin native is better than Allen sown on either date and that July 15 sown Allen is better than August 15 sown Allen.

All the seed cotton from this experiment was very stained indicating much disease.

This experiment was preceded by Mucuna which was turned in about two weeks before the seed was sown, when approximately two tons of rotten cotton seed per acre were also applied to the land.

Cotton Variety test on poor Soil.

Ilorin Native *v.* Kabba *v.* Allen.

(Table No. II).

	lb. per acre.	Odds that difference is significant.
Average yield 9 plots Native ...	73	—
„ difference 4 plots Allen ...	− 19±5·26	5,555 : 1
„ „ 4 „ Kabba ...	− 16±5·26	740 : 1

This experiment was preceded by Mucuna which was turned in about two weeks before the cotton was sown.

Here again Ilorin native proves better than Allen and also better than Kabba.

The returns are very low indeed, but they indicate that the native variety will give the higher yield under the worst conditions.

Cotton in Yams. Variety Test.

(1) Ilorin Native *v.* Allen *v.* Kabba.

(Table No. III).

	lb. per acre.	Odds that difference is significant.
Average yield 9 plots Native ...	74	
„ difference 4 plots Allen ...	−35±15·7	81 1
„ „ 4 „ Kabba ...	−1·5±15·7	–

There is no significant difference between Ilorin native and Kabba, but Allen is not nearly so good. This confirms our previous experience that Allen is not able to compete with the yams. The soil where this experiment was carried out is poor.

(2) Moulding up Cotton after yams reaped *v.* no Moulding.

(Table No. IV).

Cotton Variety—Ilorin Native.

	lb. per acre.	Odds that difference is significant.
Average yield 5 plots moulded ...	131	—
„ difference 4 plots not moulded	+ 17±13·5	8 : 1

There is a slight indication that under the conditions of the experiment it is better not to mould up the cotton after the yams have been reaped. It is possible that damage may be done to the lateral cotton roots during the operation.

(3) Cotton in yams. Single rows of Cotton *v.* Double rows of Cotton.

(Table No. V).

Variety—Ilorin Native.

	lb. per acre.	Odds that difference is significant.
Average yield 5 plots single rows ...	100	—
„ difference 4 plots double rows	+ 8±17·5	2 : 1

In this experiment it was very difficult to establish the double rows completely on account of the yam vines spreading, but a fairly good stand was established.

The indications are that no practical advantage is gained by doubling the number of plants.

Cotton with Groundnuts on poor soil.

Variety Test. Ilorin Native *v.* Allen *v.* Kabba.

(Table No. VI.)

	lb. per acre.	Odds that difference is significant.
Average yield of 9 plots, Ilorin	133	—
„ difference 4 plots Allen ...	+ 14·5 ± 13·36	6 : 1
„ „ 4 plots Kabba ...	− 20 ± 13·36	14 : 1

There is no significant difference between either of the varieties compared with Ilorin native, but there is an indication that Allen is slightly better and Kabba slightly worse than Ilorin under the conditions of the experiment.

It is interesting to note that this cotton crop was obtained from land which had already yielded a paying crop of groundnuts.

Cotton with Groundnuts on fairly rich soil.

Variety Test. Ilorin native *v.* Allen *v.* Kabba.

In this experiment more than half the plots were spoilt with the heavy rains in August and September. On this account it is of little value making any comparison but the yields are given on Table VII. It will be seen that in addition to yielding a good crop of groundnuts, a fair return of Ilorin and Allen cotton was also obtained from those plots not spoilt by the heavy rains. Here the Kabba variety did very badly.

Allen Cotton following Mucuna *v.* Allen Cotton with Groundnuts.

(Table No. VIII.)

	lb. per acre.	...	Odds that difference is significant.
Average yield of 5 plots, following Mucuna	95		—
„ difference 4 plots with G. Nuts	− 24·5 ± 12·76		34 : 1

Here there is a very strong indication that following mucuna Allen cotton yields better than when grown with groundnuts. Mucuna and groundnuts (Ilorin No. 2) were sown on April 28th. The mucuna was pulled up early in July and buried in the ridges. Allen cotton was sown on these ridges and in the furrows between the groundnuts on July 15th.

The groundnuts were reaped from September 7th to the 14th so that the cotton was occupying the ground for nearly two months with the groundnuts. This retarded the growth of the cotton nearly a month. I do not consider the test a fair one with early flowering and later flowering cotton alternating, as the earlier cotton would attract pests which would affect the later flowering cotton more than that which commenced flowering earlier. This appears to be borne out in the two five acre blocks G. 21–40 Cotton following Mucuna and G. 41–60 Cotton with groundnuts. The blocks are adjacent, but with groundnuts the average return per acre of Ilorin native as standard is 133 lb. whereas following Mucuna Ilorin native only gave 73 lb. per acre.

No material difference has been noted in the fertility of these two blocks.

Summary of cotton results.—

1. In only one instance has Allen given as good a return as Ilorin native, *i.e.* when grown with groundnuts.
2. Allen cotton is not able to compete as well as the native varieties when grown with yams.
3. Kabba variety has not yielded quite as well as Ilorin native.
4. Kabba variety was more affected by helopeltis than the other varieties. This pest delayed the crop considerably.
5. Groundnuts do not appear to affect cotton yields adversely when the cotton is sown in the furrows between the nuts some weeks before the nuts are dug, although the growth of the cotton is retarded in its early stage.
6. From the results obtained in G. 21–40 and G. 41–60 the questions arise :—Had Mucuna dug in immediately before the cotton was sown an adverse effect, or groundnuts grown with cotton as described, a beneficial effect on the cotton ?
7. Moulding up cotton grown through yams after the yams are reaped has not appeared to benefit the cotton, but rather the reverse.
8. There is little benefit to be obtained by growing two rows of cotton instead of the usual one row between each pair of rows of yams.

Groundnuts.

Groundnuts have been more extensively experimented with this season than formerly. Besides being grown as a sole crop, cotton, maize and guinea corn have been sown between the rows of groundnuts some time before the latter were ready for reaping.

As wide a range of soils as is available on the plantation was also planted with this crop.

Owing to its promising nature, details of returns, costs and values have been worked out very fully on Tables XVI, XVII and XVIII. These indicate that the crop is a profitable one to grow. 1, 2 and 3 were sown without previous preparation except weeding.

The reason for the heavy cost of (7) is that the land was new, and in heavy grass and bush, and reaping was done on a Saturday when only a half day was worked and full wages paid. The costs are therefore not fair charges to be used in making a statement of the costs of groundnuts.

An important point regarding groundnuts was the question of drying them sufficiently when reaped in August and early September. In 1924 as well as in 1925 this was done, although the September rainfall, 1925, was one of the highest on record. Nuts shelled during the rains were attacked by a Microlepidoptera, but unshelled remained in perfectly good condition. It is evident that after drying, the nuts should be stored until the dry season commences before being shelled and sold for export.

Groundnuts. Variety Test.

(Table No. IX).

Ilorin No. 2 *Versus* Zaria, Gambia and Chinese.

	Dry unshelled nuts, lb. per acre.	Odds that difference is significant.
Average yield, 13 plots, Ilorin No. 2 ...	1,301	—
Average difference, 4 plots Zaria	+ 89·5±116	4 : 1
„ „ 4 „ Gambia ...	− 129 ±116	7 : 1
„ „ 4 „ Chinese ...	− 9·5±116	1 : 1

This experiment was carried out on $\frac{1}{4}$ acre plots.

The seed was sown on March 17th. Nuts were sown unshelled at a depth of four to five inches and a good stand was produced. Plants were dug on August 31st and the nuts were dried for a week on the turned up plants before collecting was commenced. Owing to the difference in dryness, those remaining in the ground were collected separately after the others had all been got in.

The results do not show any significant difference between Ilorin, Zaria and Chinese, but there are slight indications with Gambia that they do not yield so well under the conditions of the experiment.

Last season owing to the difficulty in getting a good stand with Zaria, Gambia and Chinese, Ilorin No. 2 gave a great increase over the other varieties. The results then were as follows :—

	Dry unshelled nuts, lb. per acre.	Odds that difference is significant.
Average yield, 13 plots, Ilorin No. 2 ...	1,300	—
Average difference, 4 plots, Zaria	− 526±94	∝ : 1
„ „ 4 „ Gambia ...	− 623±94	∝ : 1
„ „ 4 „ Chinese ...	− 537±94	∝ : 1

For the two seasons Ilorin No. 2 gave the same results.

It may be that the reason for the difference in the stand obtained in the two seasons was due to one or both factors in the method of sowing which have been altered.

This Season.	Last Season.
Unshelled nuts sown.	Shelled nuts sown.
Depth sown, 5—6 inches.	2—3 inches.

The deeper sowing would give a better chance against being dried up during the period of very little rain which follows early sowing. These, however, do not explain the difference between Ilorin No. 2 and the other varieties last season.

Groundnuts. Early *v.* Late Reaping.

(Table No. X).

Variety—Ilorin No. 2. Sown April 2nd.

	Dry unshelled nuts. lb. per acre.	Odds that difference is significant.
Average yield of 5 plots reaped Sept. 2—10	1,283	—
Average difference of 4 plots reaped Nov. 3—9	− 367±46·5	$\propto$: 1

Area of plots, $\frac{1}{4}$ acre each.

The results are very conclusive, as they were with a similar experiment in 1924-25, in favour of early reaping. The low yield from late reaping is due to the earlier formed nuts spoiling in the ground.

Green Manuring Experiment.

(Table No. XI).

In 1923 a large collection of beans and cowpeas were grown to determine the most suitable for use as green manure.

Mucuna and Dolichos were far superior to any in the amount of growth made during the season.

In 1924 these two varieties were grown in alternate half acres on a block of ten acres, and in March this season, 1925, the vegetative growth was all buried.

Maize was sown throughout in ridges five feet apart. The seed was sown in double rows on the ridges. Stands two feet apart and two plants were allowed to remain at each stand.

The results are as follows :—

	Dry grain, lb. per acre.	Odds that difference is significant.
Average yield of 10 plots maize following Dolichos	960	—
Averge difference of 9 plots maize following Mucuna	$-110 \pm 109{\cdot}6$	6 : 1

No significant difference was therefore shown between the two sets of plots as a result of the preceding crop of Mucuna and Dolichos.

On July 7th Mucuna and Dolichos were sown through maize in the same plots as grew them in the previous season. Neither variety produced very luxuriant growth, but Dolichos remained in a stunted condition except in a few isolated patches.

Maize.

Ten acres of maize were grown on two five acres blocks which had been planted in the three previous years as follows :—

1922 Maize and Guinea Corn.

1923 Yams and Cotton.

1924 Mucuna.

No comparative test was made with the maize this year, the object being to determine the character of the land after a year's growth of mucuna had been turned in. The returns of dry grain per acre are given on Table XII. These indicate that the land is in exceptionally good condition.

The crop was sold locally at 25 lb. cobs for 6d. At this rate the value of a man-day works out at $10\frac{1}{2}$d. This indicates that on good land where there is a ready market, maize is a good paying crop to the native.

In one of the five acre blocks a test was made to see at what time during the growth of the maize it is advisable to sow mucuna to get a satisfactory growth before the end of the rains. The block was divided into three parts along its length. Mucuna was sown in the 1st part two weeks after the maize, in the 2nd part six weeks after the maize, and ten weeks after the maize in the remaining part. It was found that the growth made by the mucuna was much the greatest in the earliest sown and least in the latest sown. In the earliest sown there was, however, a great difficulty in preventing it from overgrowing the maize which did not occur with

the other sowing dates. By the end of the season, that sown six weeks after the maize had produced a really good growth. It was evident that this date was the most satisfactory as a good growth was obtained without any apparent interference with the maize.

Another factor was here seen which is very important from the labour point of view. When the maize was reaped, the stalks were bent over about two feet from the ground and the mucuna vines ran over these. When it was desired to turn the mucuna into the soil, it was a very easy matter compared with cutting the vines when they have spread in every direction as happens when grown without supports.

Rice.

Sowing Direct *v.* Sowing in Nursery and Transplanting.

(Table No. XIII).

	Unhusked rice, lb. per acre.	Odds that difference is significant.
Average yield of 4 plots sown direct	1,920	—
Average difference of 3 plots sown in Nursery	− 548±72·6	∞ : 1

This experiment was commenced on nine plots, but owing to damage done by floods the first and last plots have been excluded from the results. These results confirm those obtained last year when the odds were ten to one in favour of sowing direct.

Testing New Land.

Four acres of new land were sown with Guiana Creole with the exception of two plots which were sown with Maliya and Guiana 75.

The results are given on Table XIV.

It will be seen from the returns that the land is very poor, the average being only 1,022 lb. per acre. The greater part of the land was previously in grass. Most of the soil had been washed away leaving only that which had been held by grass roots. When cleared, the land had a peculiar appearance, being made up of irregular lumps of soil separated from one another by deep channels nine inches to a foot deep.

Rotation Experiment.—Three sets of three years' rotations on half acre plots each repeated twice each year were commenced in 1924. They have been continued this season, but it is too early to expect any definite results.

	A.	B.	C.
1st year ..	Maize and Beans ...	Maize and Beans ...	Groundnuts and Beans.
2nd year ...	Maize and Beans ...	Maize and Guinea Corn	Maize and Guinea Corn.
3rd year ...	Yams	Yams	Yams.

Limes.—From the two acres of limes planted out in 1915, the crop has again increased this year. Plots 25–28, which have always given a much less return than the others, are now coming more into line. Below is given the amounts reaped each year since they commenced bearing.

	Plots 21–24. (1 acre)	Plots 25 28. (1 acre)
1919	1,410 lb.	837 lb.
1920	3,120 „	780 „
1921	3,927 „	1,610 „
1922	8.038 „	2,382 „
1923	20,834 „	2,657 „
1924	26,234 „	6,982 „
1925	34,200 „	23,362 „

Coconuts.—The acre planted out in 1918 still show no sign of bearing.

THOS. THORNTON,
Superintendent of Agriculture.

Ilorin,
6th April, 1926.

TABLE No. I.

Cotton Variety Test in Rich Soil.

Plots.		Lb. per acre.	Increase (+) or decrease (−) as compared with Native.
B. 8	Native	164	
9	Allen July 15 ...	116	− 44
10	Native	156	
11	Allen August 15 ...	84	− 52
12	Native	116	
13	Allen July 15 ...	144	− 16
14	Native	204	
15	Allen August 15 ...	84	− 126
16	Native	216	
29	Native	244	
30	Allen July 15 ...	124	− 144
31	Native	292	
32	Allen August 15 ...	60	− 198
33	Native	224	
34	Allen July 15 ...	120	− 132
35	Native	280	
36	Allen August 15 ...	88	− 134
37	Native	164	
38	Native	192	Non-experimental.
39	Native	248	
40	Native	300	

Increase (+) or decrease (−) of Allen sown July 15 compared with plots in Native.	Increase (+) or decrease (−) of Allen sown August 15 compared with plots in Native.
− 44	− 52
− 16	− 126
− 144	− 198
− 132	− 134
Average − 84 ± 32·1 lb. per acre.	− 128 ± 32·1 lb. per acre.

Root − mean − square − difference 64·3 lb. per acre.

Average yield of standards 196 lb. per acre.

Size of plots ¼ acre each.

Ilorin Native sown July 1st.

Ridges : Native − 6 feet apart.

Allen − 3 „ „

Stands − 1½ „ „

TABLE No. II.

Cotton Variety Test on poor soil.

Plots.			lb. per acre.	Increase (+) or decrease (−) as compared with Ilorin
G. 21	Ilorin	... ...	100	
22	Allen	... ...	52	− 38
23	Ilorin	... ...	80	
24	Kabba	... ...	76	− 4
25	Ilorin	... ...	80	
26	Allen	... ...	60	− 14
27	Ilorin	... ...	68	
28	Kabba	... ...	56	− 14
29	Ilorin	... ...	72	
30	Allen	... ...	56	− 12
31	Ilorin	... ...	64	
32	Kabba	... ...	28	− 32
33	Ilorin	... ...	56	
34	Allen	... ...	48	− 12
35	Ilorin	... ...	64	
36	Kabba	... ...	56	− 14
37	Ilorin	... ...	76	
38	Ilorin	... ...	84	}
39	Ilorin	... ...	132	} Non-experimental.
40	Ilorin	... ...	152	}

Increase (+) or decrease (−) of Allen compared with Native (Ilorin).	Increase (+) or decrease (−) of Kabba variety compared with Native (Ilorin).
− 38	− 4
− 14	− 14
− 12	− 32
− 12	− 14
Average − 19 ± 5·26 lb. per acre.	− 16 ± 5·26 lb. per acre.

Root — mean — square — difference 10·58 lb. per acre.
Average yield of standards 73 lb. per acre.
Time of sowing — Ilorin—July 1st.
Kabba— „
Allen —July 15th.

Ridges. Ilorin — 6 ft. apart.
Kabba — 6 „ „
Allen — 3 „ „

Stands ... ... 1½ „ „
Size of plots ¼ acre each.
The Cotton was preceded by an early crop of Mucuna.

TABLE No. III.

Cotton in Yams. Variety Test.

Plots.	Yams reaped.		Yield per acre.	Increase (+) or decrease (—) compared with Ilorin.
B. 41	3,472 lb.	Ilorin	84 lb.	
42	2,688 „	Allen	48 „	—2
43	2,800 „	Ilorin	64 „	
44	2,688 „	Kabba	68 „	— 6
45	3,136 „	Ilorin	84 „	
46	2,184 „	Allen	28 „	—36
47	2,912 „	Ilorin	44 „	
48	2,240 „	Kabba	56 „	+ 6
49	3,136 „	Ilorin	56 „	
50	2,912 „	Allen	28 „	- 48
51	3,136 „	Ilorin	96 „	
52	2,688 „	Kabba	80 „	—
53	2,576 „	Ilorin	64 „	
54	2,016 „	Allen	32 „	—30
55	2,688 „	Ilorin	60 „	
56	2,912 „	Kabba	80 „	— 6
57	2,688 „	Ilorin	112 „	
58	2,352 „	Ilorin	104 „	}
59	2,576 „	Ilorin	88 „	} Non-experimental.
60	1,792 „	Ilorin	48 „	}

Increase (+) or decrease (—) of Allen compared with Ilorin.	Increase (+) or decrease (—) of Kabba compared with Ilorin.
— 26	— 6
— 36	+ 6
— 48	—
— 30	— 6

Average — 35 ± 15·7 lb per acre. Average — 1·5 ± 15·7 lb per acre

Average of standards 74 lb. per acre.

Root -- mean — square — difference 31·4 lb. per acre.

Time of Sowing Ilorin and Kabba -- July 1st.
Allen — „ 15th.

Ridges — 5 ft. apart.

Stands — 1½ ft. „

Size of plots ¼ acre each.

TABLE No. IV.

COTTON. MOULDING UP *v.* NO MOULDING UP AFTER YAMS REAPED.

Plots.	Yams reaped.		Yield cotton per acre.	Increase (+) or decrease (−) compared with cotton moulded up.
C. 41	4,116 lb.	Moulded up	184 lb.	
42	4,368 „	No Moulding up	148 „	− 10
43	4,004 „	Moulded up	132 „	
44	3,584 „	No Moulding up	140 „	+ 14
45	4,872 „	Moulded up	120 „	
46	3,808 „	No Moulding up	148 „	+ 32
47	4,424 „	Moulded up	112 „	
48	3,864 „	No Moulding up	144 „	+ 34
49	3,820 „	Moulded up	108 „	

Increase (+) or decrease (−) of Non-moulded up compared with moulded up.

− 10
+ 14
+ 32
+ 34

Average + 17·5 ± 13·5 lb. per acre.

Root—mean square-difference = 26·45 lb. per acre.

Average of standards 131 lb. per acre.

Variety of Cotton—Ilorin Native.

Ridges 5 feet apart

Stands 1½ feet apart.

Time of Sowing—July 1st.

Size of plots ¼ acre each.

TABLE V.

SINGLE ROWS OF *v.* DOUBLE ROWS OF COTTON THROUGH YAMS.

Plots.	Yams reaped.		Yield per acre.		Increase (+) or decrease (—) of Double compared with Single rows.
C. 50	2,688 lb.	Single rows	80	b.	
51	3,360 „	Double „	104	„	+ 6
52	2,912 „	Single „	116	„	
53	2,240 „	Double „	104	„	+ 2
54	2,912 „	Single „	88	„	
55	2,352 „	Double „	84	„	— 26
56	2,464 „	Single „	132	„	
57	2,240 „	Double „	140	„	+ 32
58	2,912 „	Single „	84	„	
59	2,352 „	Double „	92	„	+ 26
60	2,576 „	Single „	48	„	

Increase (−) or decrease (−) of Double compared with Single rows.

+ 6
+ 2
− 26
+ 32
+ 26

Average + 8 ± 17·5 lb. per acre.

Root − mean − square − difference 39 lb. per acre.

Average yield of standards 100 lb. per acre.

Variety of Cotton — Ilorin Native.

Time of Sowing — July 1st.

Size of plots — ¼ acre each.

Ridges — 5 ft. apart.

Stands — 1½ ft. „

TABLE No. VI.

Cotton with Groundnuts on poor soil. Variety Test.

Plots.	Yield of dry unshelled nuts per plot.		Cotton yield per acre.	Increase (+) or decrease (−) compared with Ilorin.
G. 41	205 lb	Ilorin	124 lb	
42	231 „	Allen	148 „	+ 38
43	240 „	Ilorin	96 „	
44	206 „	Kabba ...	76 „	− 18
45	201 „	Ilorin	92 „	
46	206 „	Allen	132 „	+ 12
47	293 „	Ilorin	148 „	
48	260 „	Kabba ...	116 „	− 32
49	247 „	Ilorin	148 „	
50	224 „	Allen	148 „	− 2
51	244 „	Ilorin	152 „	
52	244 „	Kabba ...	136 „	− 26
53	263 „	Ilorin	172 „	
54	248 „	Allen	168 „	+ 10
55	276 „	Ilorin	144 „	
56	260 „	Kabba ...	128 „	− 4
57	256 „	Ilorin	120 „	
58	257 „	Ilorin	152 „	
59	266 „	Ilorin	124 „	Non-experimental.
60	294 „	Ilorin	136 „	

Increase (+) or decrease (−) of Allen compared with Ilorin.	Increase (+) or decrease (−) of Kabba compared with Ilorin.
+ 38	− 18
+ 12	− 32
− 2	− 26
+ 10	− 4
Average + 14·5 ± 13·3 lb per acre.	Average − 20 ± 13·3 lb per acre.

Root-mean-square-difference = 26·7 lb per acre.

Average yield of standards = 133 lb per acre.

Size of plots $\frac{1}{4}$ acre each.

Time of sowing Groundnuts, March 17th.

Time of reaping Groundnuts, August 24th—September 7th.

Time of sowing cotton: Ilorin and Kabba—July 1st. Allen—July 15th.

Distances between rows: Ilorin and Kabba 6 feet. Allen—3 feet.

TABLE No. VII.

GROUNDNUTS AND COTTON VARIETY TEST.

Plots.	Yield of dry unshelled nuts.		Cotton yield per acre.	
D. 29	401 lb.	Ilorin	112 lb.	
30	394 „	Ilorin	176 „	
31	403 „	Kabba	64 „	
32	451 „	Ilorin	204 „	
33	364 „	Allen	160 „	
34	453 „	Ilorin	160 „	
35	398 „	Kabba	56 „	
36	398 „	Ilorin	172 „	
37	355 „	Allen	120 „	
38	417 „	Ilorin	92 „	
39	393 „	Kabba	48 „	
40	331 „	Ilorin	60 „	
41	326 „	Allen	36 „	
42	384 „	Ilorin	44 „	Spoilt by land becoming sodden during August and September.
43	391 „	Kabba	40 „	
44	347 „	Ilorin	48 „	
45	301 „	Allen	64 „	
46	386 „	Ilorin	64 „	
47	349 „	Ilorin	80 „	
48	296 „	Ilorin	80 „	

Size of plots ¼ acre each.

Distances between rows :—Ilorin and Kabba—6 ft. Allen 3 ft.

Time of sowing nuts—April 3rd

Time of reaping nuts—September, 7th—17th.

Time of sowing cotton—Ilorin and Kabba—July 1st. Allen July 15th.

TABLE No. VIII.

MUCUNA AND ALLEN COTTON *v.* GROUNDNUTS AND ALLEN COTTON.

Plots.			Yield of unshelled nuts per plot.	Yield of Cotton per acre.	Increase (+) or decrease (−) of cotton with groundnuts compared with cotton and mucuna.
E2.	1	Mucuna ...	...	60 lb.	
	2	Groundnuts ...	231 lb.	48 „	− 34
	3	Mucuna ...	...	104 „	
	4	Groundnuts ...	231 lb.	60 „	− 42
	5	Mucuna ...	...	100 „	
	6	Groundnuts ...	228 lb.	104 „	− 4
	7	Mucuna ...	...	116 „	
	8	Groundnuts ...	183 lb.	88 „	− 18
	9	Mucuna ...	...	96 „	

Increase (+) or decrease (−) of cotton with groundnuts compared with cotton and mucuna.

− 34
42
− 4
− 18

Average − 24·5 ± 12·76 lb. per acre.

Root—mean—square—difference = 25·5 lb. per acre.

Average yield of standards = 95 lb. per acre.

Size of plots $\frac{1}{4}$ acre each.

Ridges—3 feet apart.

Stands—$1\frac{1}{2}$ feet apart.

Time of sowing Groundnuts, April 28th.

„ „ reaping „ „ September 7th—17th.

„ „ sowing Cotton, July 15th.

TABLE No. IX.

GROUNDNUTS—VARIETY TEST.

Plots.	Variety.	Unshelled dry nuts per plot.	Unshelled dry nuts per acre.	Increase (+) or Decrease (−) as compared with the mean of adjacent standard.
Block G.				
61	Ilorin No. 2 ...	379	1,516	
62	Zaria	438	1,752	+ 306
63	Ilorin No. 2 ...	344	1,376	
64	Gambia ...	296	1,184	− 222
65	Ilorin No. 2 ...	359	1,436	
66	Chinese ...	357	1,428	+ 22
67	Ilorin No. 2 ...	344	1,376	
68	Zaria	356	1,424	+ 64
69	Ilorin No. 2 ...	336	1,344	
70	Gambia ...	278	1,112	− 262
71	Ilorin No. 2 ...	351	1,404	
72	Chinese ...	278	1,112	− 106
73	Ilorin No. 2 ...	258	1,032	
74	Zaria	347	1,388	+ 196
75	Ilorin No. 2 ...	338	1,352	
76	Gambia ...	302	1,208	+ 2
77	Ilorin No. 2 ...	265	1,060	
78	Chinese ...	297	1,188	+ 160
79	Ilorin No. 2 ...	249	996	
80	Zaria	224	896	− 208
81	Ilorin No. 2 ...	303	1,212	
82	Gambia ...	288	1,152	− 34
83	Ilorin No. 2 ...	290	1,160	
84	Chinese ...	323	1,292	− 114
85	Ilorin No. 2 ...	413	1,652	

Increase (+) or Decrease (−) of Zaria compared with Ilorin No. 2.	Increase (+) or Decrease (−) of Gambia compared with Ilorin No. 2.	Increase (+) or Decrease (−) of Chinese compared with Ilorin No. 2.
+ 306	− 222	+ 22
+ 64	− 262	− 106
+ 196	+ 2	+ 160
− 208	− 34	− 114
Average + 89·5 ± 116 lb. per acre.	− 129 ± 116 lb. per acre	− 9·5 ± 116 lb. per acre.

Root—mean—square—difference between neighbouring pairs of control plots = 233 lb. per acre.

Average yield per acre of control plots = 1,301 lb. per acre.

Size of plots $\frac{1}{4}$ acre.

Seed Sown March 17th. Reaped August 31st to September 16th.

Cost of cultivation in man-days per acre = 116.

TABLE No. X.

GROUNDNUTS.

Early v. Late Reaping.

Variety—Ilorin No. 2.

Block.	Plots.	When Reaped.	Dry unshelled nuts per plot.	Dry unshelled nuts per acre.	Increase (+) or decrease (−) of Late reaping compared with mean of adjacent standards.
G	86	Early ...	321 lb.	1,284 lb.	
	87	Late ...	190 „	760 „	− 526
	88	Early ...	322 „	1,288 „	
	89	Late ...	243 „	972 „	− 362
	90	Early ...	345 „	1,380 „	
	91	Late ...	250 „	1,000 „	− 342
	92	Early ...	326 „	1,304 „	
	93	Late ...	248 „	992 „	− 240
	94	Early ...	290 „	1,160 „	

Increase (+) or decrease (−) of Late compared with Early reaping.

− 526

− 362

− 342

− 240

Average − 367 ±46·5 lb. per acre.

Root—mean—square—difference = 93 lb. per acre.

Average yield of control plots = 1,283 lb. per acre.

Date Sown—April 2nd.

Date Reaped—Early, September 2nd–10th.

Late, November 3rd–9th.

Size of plots—1/4th acre

TABLE No. XI.

Maize following Dolichos and Mucuna which were grown for whole season 1924-25 and turned in during March this Season.

Plots.	Preceding crop.	Dry grain per plot.	Dry grain per acre.	Increase (+) or decrease (−) of Maize following Mucuna compared with Maize following Dolichos.	Increase (+) or decrease (-) of Maize following Mucuna compared with Maize following Dolichos.
Block A.					
62	Dolichos ...	858	1,716		
64	Mucuna ...	578	1,156	− 499	− 499
66	Dolichos ...	797	1,594		
68	Mucuna ...	765	1,530	− 204	− 204
70	Dolichos ...	937	1,874		
72	Mucuna ...	617	1,234	− 270	− 270
74	Dolichos ...	567	1,134		
76	Mucuna ...	524	1,048	− 61	− 61
78	Dolichos ...	542	1,084		
80	Mucuna ...	415	830	+ 16	+ 16
82	Dolichos ...	272	544		
84	Mucuna ...	188	376	− 120	− 120
86	Dolichos ...	224	448		
88	Mucuna ...	191	382	− 1	− 1
90	Dolichos ...	159	318		
92	Mucuna ...	230	460	+ 79	+ 79
94	Dolichos ...	222	444		
96	Mucuna ...	255	519	+ 65	+ 65
98	Dolichos ...	223	446		
100	Mucuna ...	215	430		

Increase (+) or decrease (-) of Maize following Mucuna compared with Maize following Dolichos.
− 499
− 204
− 270
− 61
+ 16
− 120
− 1
+ 79
+ 65
Average − 110 ± 109·6 lb. per acre.

Root—mean—square—difference = 329 lb. per acre.
Average return per acre of standard Plots = 960 lb.
Percentage of dry grain to cobs reaped = 66·5.
Size of plots $\frac{1}{2}$ acre.
Seed Sown May 4th. Reaped September 2nd.
Cost of cultivation in man-days per acre = 54.

TABLE No. XII.

MAIZE RETURNS : 1925.

Block.	Plot.	Date Sown.	Date Reaped.	Returns of dry grain per acre.
A.	1	May 4th ...	August 27th ...	2072
	2	,, ...	,, ...	1796
	3	,, ...	,, ...	1288
	4	,, ...	,, ...	1208
	5	,, ...	,, ...	1912
	6	,, ...	,, ...	1760
	7	,, ...	,, ...	1672
	8	,, ...	,, ...	1508
	9	,, ...	,, ...	1628
	10	,, ...	,, ...	1584
	11	,, ...	,, ...	2024
	12	,, ...	,, ...	1788
	13	,, ...	,, ...	1732
	14	,, ...	,, ...	1904
	15	,, ...	,, ...	1984
	16	,, ...	,, ...	1504
	17	,, ...	,, ...	1452
	18	,, ...	,, ...	1740
	19	,, ...	,, ...	1872
	20	,, ...	,, ...	1768
				Average 1709 lb. per acre.
C.	1	May 4th ...	Aug. 25th & 26th	1320
	2	,, ...	,, ,,	1276
	3	,, ...	,, ,,	1396
	4	,, ...	,, ,,	1424
	5	,, ...	,, ,,	1356
	6	,, ...	,, ,,	1448
	7	,, ...	,, ,,	1476
	8	,, ...	,, ,,	1540
	9	,, ...	,, ,,	1464
	10	,, ...	,, ,,	692 Site of old Quarter-master's house
	11	,, ...	,, ,,	880
	12	,, ...	,, ,,	1448
	13	,, ...	,, ,,	1556
	14	,, ...	,, ,,	1600
	15	,, ...	,, ,,	1672
	16	,, ...	,, ,,	1528
	17	,, ...	,, ,,	1832
	18	,, ...	,, ,,	1800
	19	,, ...	,, ,,	1632
	20	,, ...	,, ,,	1476
				Average 1441 lb. per acre.

Percentage of grain to cobs = 66·5%.
Ridges 6 feet apart. Stands 2 feet apart. 2 plants at each stand.
Seed sown on each side of ridge.
Variety : Ilorin Native.
1925—Maize followed by Mucuna (Mucuna interplanted with the maize).
1924—Mucuna
1923—Yams and Cotton.
1922—Maize and Guinea Corn.

TABLE No. XIII.

RICE—SOWING DIRECT *versus* SOWING IN NURSERY AND TRANSPLANTING.

Plots	How sown.	Amount reaped per plot in lb.	Amount per acre in lb.	Increase (+) or Decrease (−) of sowing in nursery compared with sowing direct.
Block A. 1	Nursery ...	103	1,030	
2	Direct ...	208	2,080	
3	Nursery ...	167	1,670	− 305
4	Direct ...	187	1,870	
5	Nursery ...	118	1,180	− 675
6	Direct ...	184	1,840	
7	Nursery ...	120	1,200	− 665
8	Direct ...	189	1,890	
9	Nursery ...	102	1,020	

Results are given as dry unhusked grain.

Sown June 10th.

Reaped November 17th to 26th.

Plots 1/10 acre.

Ridges 3 feet apart.

Stands 9 inches apart on both sides of ridges.

Variety—Guiana Creole.

Increase (+) or decrease (−) of sowing in nursery compared with sowing direct.

− 305
675
− 665

Average − 548±72·6 lb. per acre.

Root-mean-square-difference=125 lb. per acre.

Average return per acre of standard plots=1,920 lb. per acre.

TABLE No. XIV.

Rice.—Test of New Land For Rice.

Returns per plot in lb.

Block.	Plots:— 1	2	3	4	5	6	7	8	9	10
E	138	111	89	59	73	65	83	102	102	158
D	98	106	108	94	122	134	99	108	110	129
C	97	156	105	91	83	71	7	95	106	95
B	117	113	125	109	69	81	109	117	G. 75 89	Maliya 102

All except those specially marked are Guiana Creole.

Seed sown direct on June 9th.

Reaped November 16th–26th.

Plots $\frac{1}{10}$ acre.

Ridges 3 feet apart.

Stands 9 inches apart on both sides of ridges.

B is nearest and E is farthest away from the river.

TABLE No. XV.

Costs and Values.

Block.	Plots.	Experiment.	Acreage.	Returns per acre.	Price per ton.	Value per acre.	Cost per acre.	Man-days per acre.	Value per man-day.	
				In cob.	In cob.					
					£ s. d.	£ s. d.	£ s. d.			
A.	61–100	Maize.	10	1,329 lb.	2 4 8	1 6 6	1 19 3	53	6d.	Very poor soil.
A.	1–20	Maize.	10	2,370 lb.	2 4 8	2 7 5	1 19 8	53	10½d.	Good soil.
C.	1–20									
B.	41–60	Yams.	10	6,164 lb.	1 10 0	4 2 6	4 5 11	114	8½d.	Poor soil.*
C.	41–60									
		Rice.	$4\frac{9}{10}$	Unhusked 1,116 lb.	7 11 8	3 19 7	7 9 0	199	5d.	Poor soil.

* Yams planted deducted from returns, then 25%, more deducted to account for loss due to drying and waste.

TABLE No. XVI.

Groundnuts, Costs and Values.

Description.	Average.	Average return per acre dry unshelled, in lb.	Average return per acre of shelled nuts at 70% of unshelled, in lb.	Cost per acre unshelled nuts.	Cost per acre shelled nuts.	Cost per acre shelled nuts in man-days.	Cost per ton unshelled.	Cost per ton shelled, shelling cost 20/- per ton.	Value per acre @ £12 per ton shelled.	Value per man-day for production of shelled nuts.
				£ s. d.	£ s. d.		£ s. d.	£ s. d.	£ s. d.	
(1) Block D. G. Nuts preceding cotton ...	5	1,507	1,055	4 10 11	5 0 0	133	6 15 0	10 15 0	5 13 0	10·2d.
(2) Block G. G. Nuts preceding cotton ...	5	984	688	3 2 6	3 8 6	91	7 2 0	11 3 0	3 13 8	9·6d.
(3) Block G. G. Nuts preceding maize ...	¾	1,178	825	4 4 7	4 11 6	122	8 0 0	12 9 0	4 8 6	8·7d.
(4) Block G. G. Nuts preceding G. Corn ...	¾	1,066	746	3 8 1	3 14 6	99	7 3 0	11 4 0	4 0 0	9·7d.
(5) Rotation. G. Nuts preceding mucuna ...	1	1,330	931	4 11 6	4 19 6	133	7 14 0	12 0 0	4 19 9	9d.
(6) Block G. G. Nuts Variety Test	6¼	1,281	897	3 18 10	4 7 0	116	6 18 0	10 17 0	4 16 0	9·9d.
(7) Block E². G. Nuts preceding cotton	1	873	610	5 6 3	5 11 0	146	13 12 0	20 9 0	3 5 3	5·3d.

TABLE No. XVII.

Returns and Values of Late Maize and Guinea Corn following Groundnuts Grown on Poor Soil.

Block.	Plots.	Average return per acre unshelled nuts.	Average return per acre grain.	Cost of ground-nuts per acre.	Cost of grain per acre.	Combined cost of both crops per acre.	Value of unshelled nuts.	Value of grain.	Combined value of both crops.	Cost in man-day per acre ground nuts.	Cost in man-day per acre grain.	Value man-day for ground nuts.	Value man-day for grain.
G.	95	1,178 lb.	Maize 372 lb.	£4 5 4	Maize £1 15 0*	£6 0 4	£4 1 0	Maize £0 15 6	£4 16 6	113	Maize 46	8·6d.	Maize 4d.
	96												
	97												
	98	1,066 lb.	G. Corn. 433 lb.	£3 13 0	G. Corn £1 12 0	£5 5 0	£3 13 6	G. Corn £0 15 6	£4 9 0	97	G. Corn 42	9·1d.	G. Corn 4·4d.
	99												
	100												

Value per man-day Groundnuts and Maize ... ... 7·3d.

" " " " Guinea Corn ... ... 7·7d.

* In addition to above charges £2 5s. 0d. was spent on a watchman to keep off monkeys. As only ¾ acre was grown the charge was very high but it was done to be sure that the full crop was obtained.

TABLE XVIII.

Cost and Values Cotton combined with other Crops.

Block.	Plots.	Acres.	*Cotton* Average return per acre.	Average cost per acre.	Man-days.	Value per acre as Grade II –15% for waste.	Value per man-day in pence.	Crop combined with Cotton.	Average return per acre.	Average cost per acre.	Average value per acre.	Value per man-day in pence.	Value per man-day of combined Crops.
				£ s. d.						£ s. d.	£ s. d.		
G.	41–60	3	N.I.C.—133 lb.	2 11 8	69	11/7	1·8	*Ground Nuts* returns given as shelled *Nuts.*	688 lb.	3 8 6	3 13 8	9·6	6·4
		1	Allen — 149 „	2 13 1	71	19/7	3·3						6·9
		1	Kabba—114 „	2 11 8	69	9/1	1·6						6·2
C.	41–60	4	N.I.C. Moulded — 115 lb.	1 1 2	28	9/2	4·0	*Yams.*	6,164 „	4 5 11	4 2 6	8·5	7·0
		1	Non-moulded — 145 „	0 14 8	20	11/6	6·9						8·4
B.	8–16 & 29–40	3¼	N.I.C.—208 lb.	3 3 6	85	16/7	2·3	*Mucuna**	—	0 19 3	—	—	1·8
		1	Allen —126 „ (July sown)	3 3 3	84	16/9	2·4						1·8

* The Mucuna was turned in and land manured with 2 tons of rotten cotton seed per acre when ridging in preparation for the cotton.

The cost of turning in Groundnut Tops, Yam and Mucuna Vines, although charged above against cotton, is not a fair charge against the cotton, as the manurial value is probably more permanent than that crop.